Total Maximum Daily Load for *E. coli* in Brush Creek (USGS HUC 05130102060140) and Crooked Creek (USGS HUC 05130102060180) of Roundstone Creek, Rockcastle County Kentucky

Proposed TMDL

Submitted to:
United States Environmental Protection Agency
Region IV
Atlanta Federal Building
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Atlanta, GA 30303-1534

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Kentucky Department for Environmental Protection
Division of Water

This report is approved for release

David W. Morgan

David W. Morgan, Director
Division of Water

8/9/06
Date

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Summary Sheet

Total Maximum Daily Load (TMDL)

1. 303(d) Listed Waterbody Information

   State: Kentucky
   County: Rockcastle
   Major River Basin: Upper Cumberland River
   8-Digit HUC: 05130102
   GNIS #: Brush Creek = 510966_00
   Crooked Creek = 511648_00

Waterbody	River Mile	Listing Year	Use Impairment(s)	Pollutant
Brush Creek	1.1 – 7.5	1998	Primary contact recreation	Pathogens
Crooked Creek	1.0 – 6.4	1998	Primary contact recreation	Pathogens

2. TMDL Target (numerical/narrative target):

The TMDL target is the Kentucky water quality criterion for Primary Contact Recreation of 240 cfu/100 ml *Escherichia coli* (*E. coli)* as stated in 401 KAR 5:031 Section 7(1)(a).

3. Pollutant Allocations:

Brush Creek

Site Name	Critical Flow Condition	Load (BoC/ day)[1]	TMDL Target Load	WLA		LA		MOS	
				(BoC/day)	% Reduction	(BoC/day)	% Reduction	(BoC/day)	% of TMDL
TMDL01BC Lower Brush Creek	36%	105.86	16.17	0.00[2]	0.0%	14.55	85%	1.62	10.0
TMDL02BC Upper Brush Creek	65%	21.85	2.95	0.00[2]	0.0%	2.65	88%	0.3	10.0

[1] Billions of colonies per day

[2] Any future permitted point source must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment.

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Crooked Creek

Site Name	Critical Flow Condition	Existing Load (BoC/day)[1]	TMDL Target Load (BoC/day)[1]	WLA		LA		MOS	
				(BoC/day)[1]	% Reduction	(BoC/day)[1]	% Reduction	(BoC/day)[1]	% of TMDL
TMDL01CC Lower Crooked Cr.	36.5%	416.31	41.62	0.00[2]	0.0%	37.46	91%	4.16	10%
TMDL02CC Lower Middle Crooked Cr.	46.9%	75.71	19.73	0.00[2]	0.0%	17.76	**[3]	1.97	10%
TMDL03CC Upper Middle Crooked Cr.	8.0%	465.17	136.81	0.00[2]	0.0%	123.13	**[3]	13.68	10%
TMDL04CC Upper Crooked Cr.	51.0%	11.60	9.04	0.00[2]	0.0%	8.14	**[3]	0.90	10%
TMDL05CC UT to Crooked Cr. Below TMDL02CC	38.6%	71.29	5.52	0.00[2]	0.0%	4.97	93%	0.55	10%

[1] Billions of colonies per day
[2] Any future permitted point source must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment.
[3] Less than 10% of the samples collected violated the WQC, therefore no load reduction was calculated.

4. Endangered Species (yes or no):

No

5. TMDL Proposal Date:

08/31/2006

6. TMDL Impacted by Point Source, Nonpoint Source, or both:

Nonpoint Source only

7. Major KPDES Discharges to Surface Waters:

None

1.0 Introduction

1.1 Background

Section 303(d) of the Clean Water Act requires states to identify waters within their boundaries that have been assessed and are not currently meeting water quality standards (WQS) for their designated uses. Listed waters are prioritized for Total Maximum Daily Load (TMDL) development. This report presents the development of a TMDL for *Escherichia coli* (*E. coli)* in Brush Creek and Crooked Creek of Roundstone Creek watersheds. The development of a TMDL requires an assessment of current pollutant loads, sources of pollution within the watershed, a determination of the assimilative capacity of the stream for the pollutant and recommendations for reductions of the pollutant from both point and nonpoint sources.

1.2 Problem Definition

Brush Creek was placed on the 1998 303(d) List of Waters for Kentucky and designated as first priority for violations of the Primary Contact Recreation (PCR) standard (KDOW 1998) for river miles 1.1 – 7.5. The suspected sources of pollution are agriculture and onsite wastewater systems (septic tanks and/or straight pipes). Crooked Creek was also placed on the 1998 303(d) list as a second priority segment for partial support of the PCR designated use for river miles 1.0 to 6.4 (KDOW 1998). The suspected sources of pollution are agriculture and onsite wastewater systems (septic tanks and/or straight pipes).

1.3 Watershed Descriptions

Brush Creek of Roundstone Creek (GNIS 510966) is located in Rockcastle County and comprises United States Geological Survey (USGS) Hydrologic Unit Code (HUC) 05130102060140 (Figure 1). The watershed drains an area of 9.56 square miles. According to the National Hydrology Dataset (NHD 24k) there are 20.83 total stream miles in the Brush Creek watershed with a slope of 1.5% (Figure 2). Crooked Creek of Roundstone Creek (GNIS 511648) is also located in Rockcastle County and is contained in USGS HUC 0513102060180 (Figure 1). The watershed drains an area of 21.8 square miles. The NHD 24k contains 52.65 total stream miles with an overall slope of 0.21% (Figure 3).

Both watersheds lie entirely within the Southwestern Appalachians Level III Ecoregion, the Plateau Escarpment Level IV Ecoregion and the Eastern Pennyroyal Physiographic Region (Woods et al. 2002). The Plateau Escarpment Ecoregion is characterized by narrow ridges, cliffs and gorges. The uplands are underlain by Pennsylvanian strata which include sandstone and coal. The valleys and lower slopes typically contain Mississippian carbonates. The Kentucky Division of Water (KDOW) rates both watersheds as highly susceptible to groundwater contamination due to the hydrogeologic sensitivity of the area (Ray et al. 1994). The dominant soil types in these watersheds are Shelocta-Rigley-Latham association and the Shelocta-Latham-Brookside association. The Shelocta-Rigley-Latham association is described as sloping to very steep with deep soils (>40 in) that have loamy subsoil on side slopes. Narrow ridgetops are found to be moderately steep and moderately deep with clayey subsoil. The Shelocta-Latham-Brookside association is sloping to very steep with deep soils (>40 in) that mainly have a clayey subsoil on the ridgetops and upper slopes and with a loamy subsoil on the lower slopes (USDA 1981).

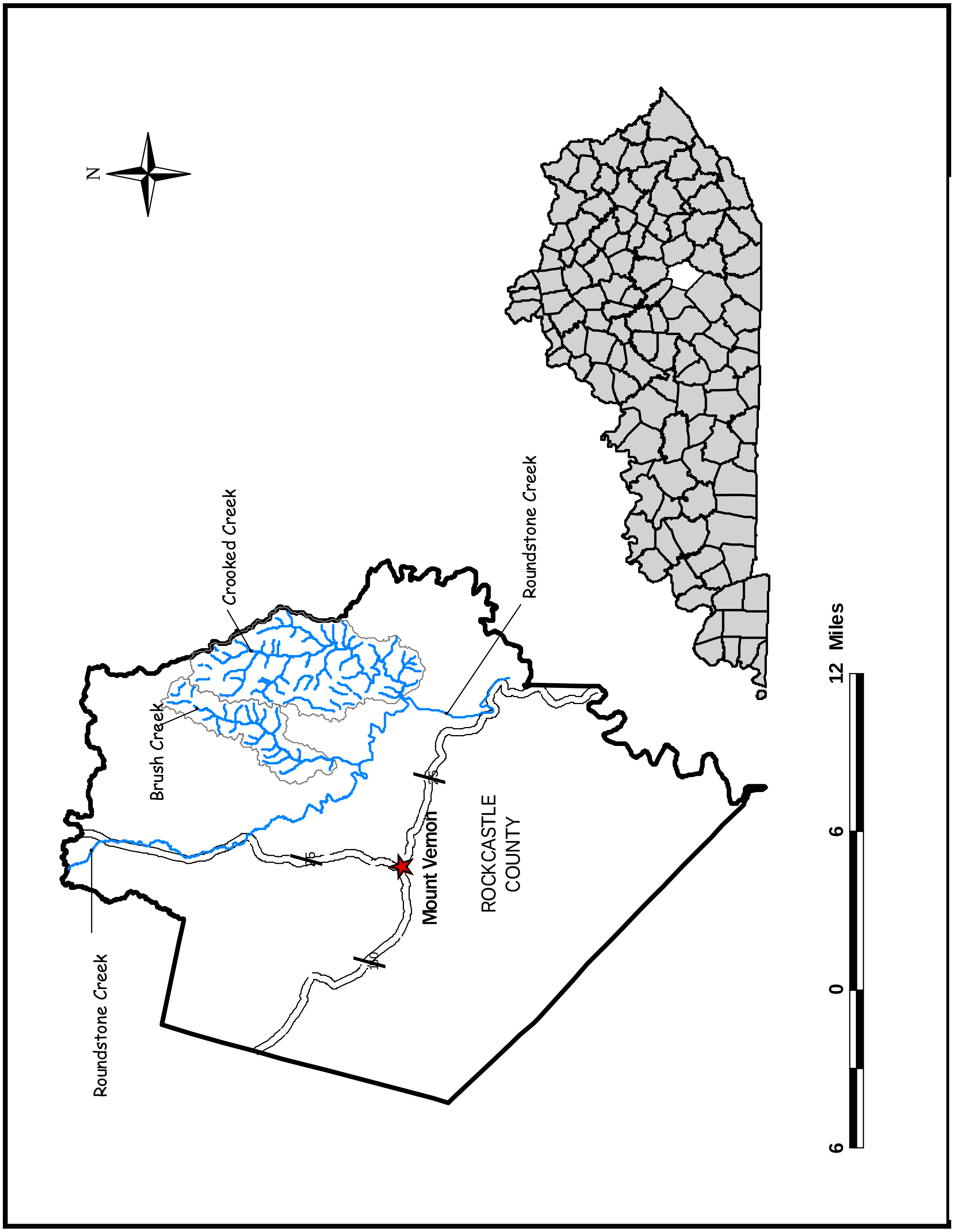

Figure 1. Location of Brush Creek and Crooked Creek in Northeastern Rockcastle County

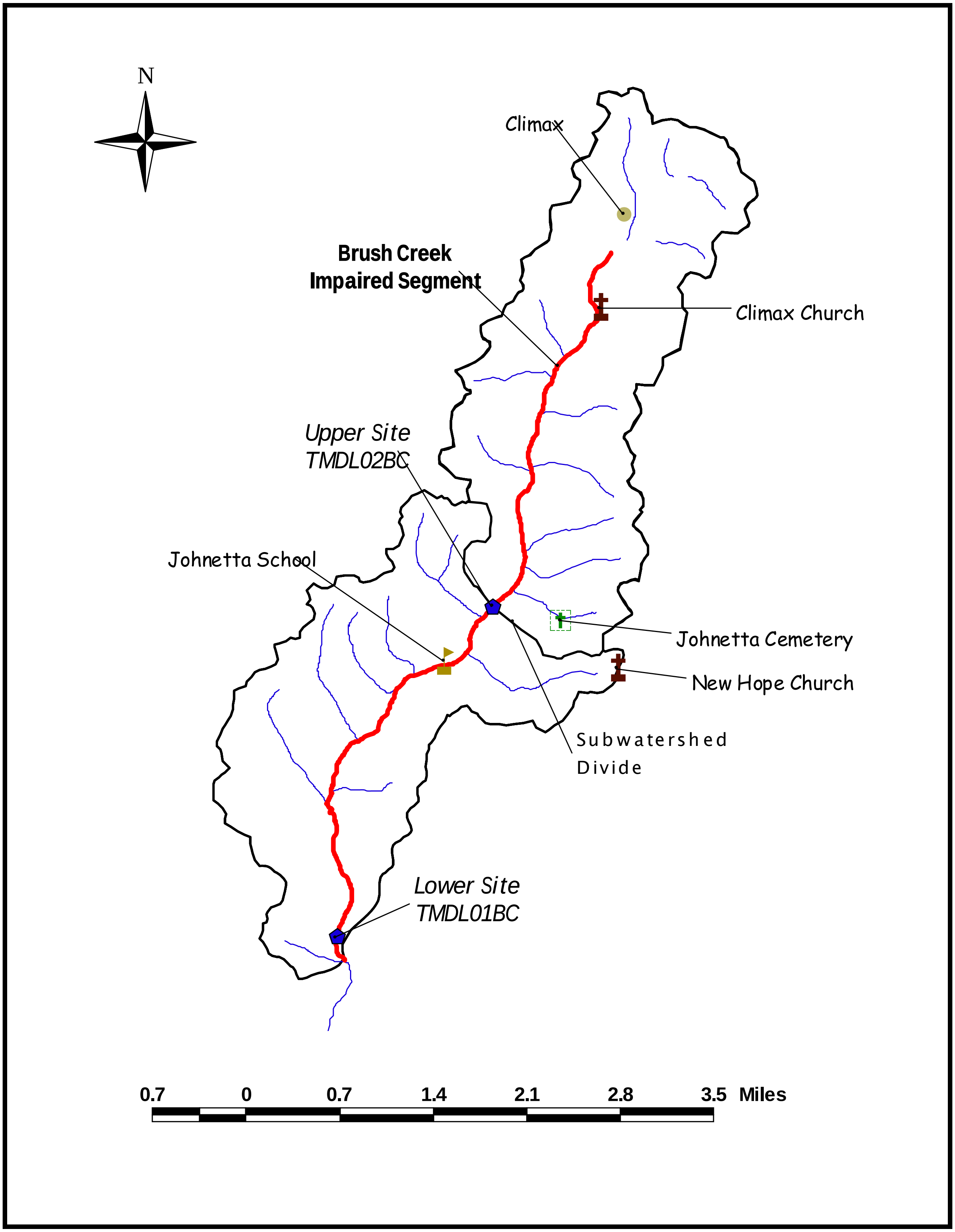

Figure 2. Map of Sub-watersheds and Impaired Segment of Brush Creek

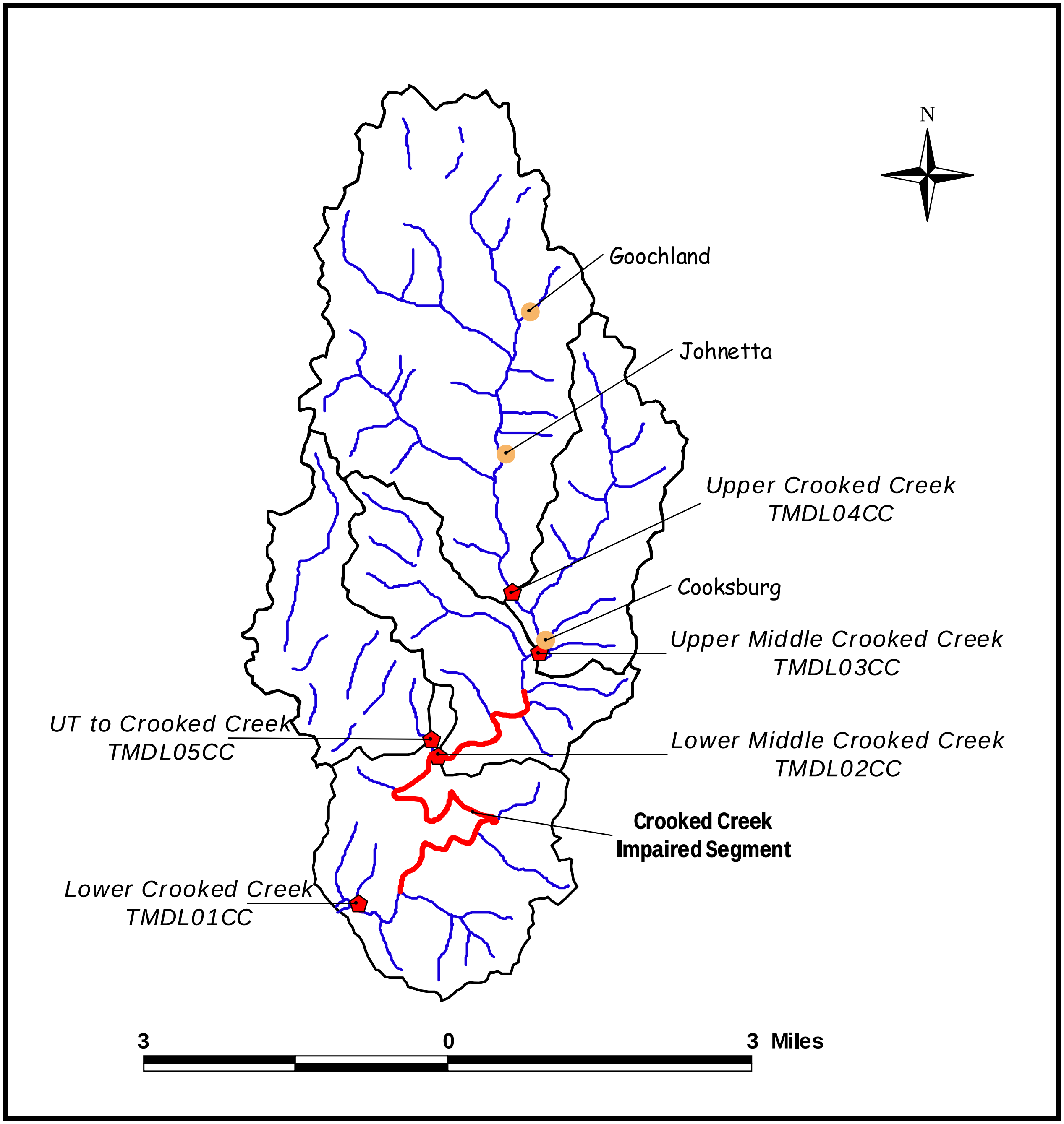

Figure 3. Map of Sub-watersheds and Impaired Segment of Crooked Creek

1.3.1 Landuse Distribution

The National Land Cover Dataset (NLCD, USGS 2001) was used to determine the land use within the Brush Creek and Crooked Creek watersheds. The percentage of Landuse by subwatershed was calculated using the Analytical Tools Interface for Lanscape Assessments (ATtILA, USEPA 2004) extension in Arcview GIS 3.2a (ESRI 2000). Brush Creek is predominantly a forested watershed (76%) followed by pasture (14%) and developed (residential, commercial and transportation) (10%). The upper portion of the watershed is considerably less forested (68%) than the lower portion (84%). There is also much more agricultural activity in the upper portion of the watershed (pasture-19.6% Figure 4 and Table 1). Crooked Creek is also dominated by forested land (79%). There is a relatively high percentage (10-13%) of agricultural activity in the upper sections of the watershed compared to the lower sections (3-7% Table 2 and Figure 5).

Table 1. NLCD Land Use Distribution in Brush Creek, Rockcastle County

Land Use	Brush Creek Entire HUC 14		TMDL01BC Lower Subwatershed		TMDL02BC Upper Subwatershed	
	Acres	% Area	Acres	% Area	Acres	% Area
Forest	4645.8	75.90	2463.9	84.14	2181.9	68.37
Pasture	844.0	13.80	219.5	7.50	449.0	19.60
Developed	589.5	9.63	238.2	8.13	351.4	11.01
Barren	2.7	0.04	0.0	0.00	2.7	0.08

Table 2. NLCD Land Use Distribution in Crooked Creek, Rockcastle County

Land Use	Crooked Creek Entire HUC 14		TMDL01CC Lower Crooked Creek		TMDL02CC Lower Middle Crooked Creek		TMDL03CC Upper Middle Crooked Creek		TMDL04CC Upper Crooked Creek		TMDL05CC UT to Crooked Creek below TMDL02CC	
	Acres	% Area	Acres	% Area	Acres	% Area	Acres	% Area	Acres	% Area	Acres	% Area
Forest	12176.2	79.44	2497.92	83.08	1892.7	86.76	1723.2	81.17	4566.3	75.64	1496.1	76.07
Pasture	1578.3	10.30	217.84	7.25	76.0	3.48	215.8	10.16	842.6	13.94	81.2	4.13
Developed	1503.3	9.81	290.79	9.67	205.5	9.42	181.9	8.57	619.6	10.26	205.5	10.45
Barren	16.4	0.11	4.11	0.14	1.0	0.05	5.1	0.25	2.1	0.03	4.1	0.21

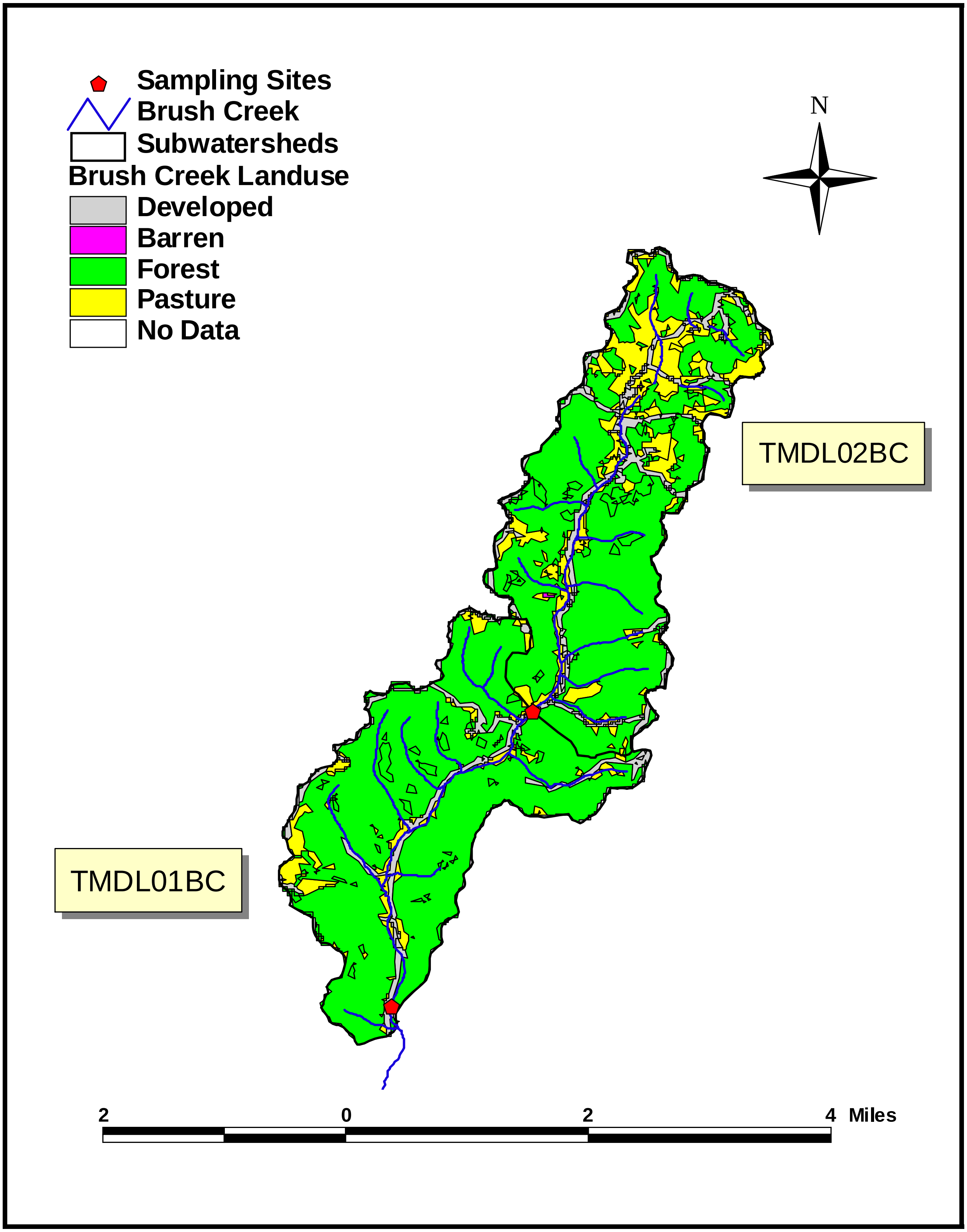

Figure 4. Landuse Map of Brush Creek Watershed

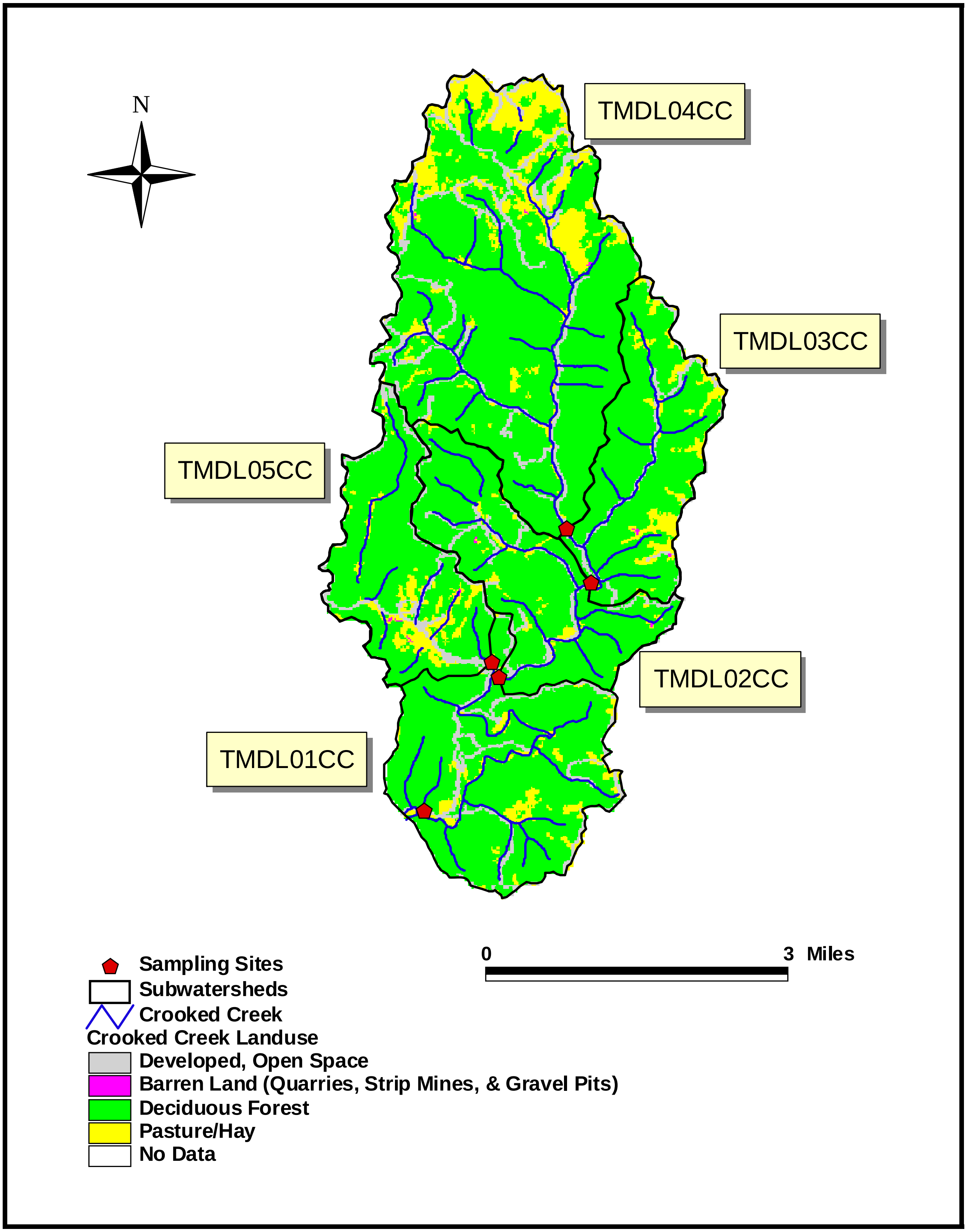

Figure 5. Landuse Map of the Crooked Creek Watershed

2.0 Target Identification

The water quality criteria (WQC) for *E. coli* concentrations in primary contact recreation waters are defined in 401 KAR 5:031 7(a) as 130 colonies per 100 ml as a geometric mean based on not less than five (5) samples taken during a thirty (30) day period, and concentrations shall not exceed 240 colonies per 100 ml in twenty (20) percent or more of samples taken in a thirty day period. There were insufficient data to calculate the geometric mean for *E. coli* based on KDOW 2005 sampling, therefore the TMDL will be based on the acute criterion of 240 colonies per 100 ml.

3.0 Monitoring

The KDOW monitored two sites in the Brush Creek watershed from May 2005 to October 2005 (Figure 6). There were nine (9) samples collected from the lower site (TMDL01BC) with one (1) sample violating the WQC (Table 3). Samples were not collected at TMDL01BC in late July or August due to the presence of a beaver dam just downstream causing ponding at the sample location. There were twelve (12) samples taken from the upper site (TMDL02BC) with eleven (11) violations of the WQC (Table 3). The data from each sampling event are found in Appendix B.

The KDOW monitored five sites in the Crooked Creek watershed from May 2005 to October 2005 (Figure 6). There were a total of 12 samples collected from each site. The number of violations ranged from one (1) in the middle and upper reaches to five (5) in the lower reach, with three (3) violations occurring in the UT to Crooked Creek (Table 3). The data from each sampling event are found in Appendix B.

If less than ten (10) percent of the samples met the WQC, then no load reduction was calculated and the segment was assessed as meeting the water quality standard. Using a ten (10) percent threshold is more conservative than the actual standard of twenty (20) percent as defined in 401 KAR 5:031 7(a). Three segments of Crooked Creek were considered to be meeting the water quality standard with only one (1) violation in twelve (12) samples. This is not to be an assessment of the entire 303(d) listed segment, rather an assessment of the specific reaches sampled. Also note that TMDL03CC (Upper Middle) and TMDL04CC do not fall within the 303(d) impaired segment.

Table 3. KDOW Monitoring Summary in Brush and Crooked Creek

Stream	Site Description	Samples Collected	Violations of WQC	% Violations
Brush Creek				
TMDL01BC	Lower Brush Creek	9	1	11%
TMDL02BC	Upper Brush Creek	12	11	92%
Crooked Creek				
TMDL01CC	Lower Crooked Creek	12	4	33%
TMDL02CC	Lower Middle Crooked Creek	12	1	8%
TMDL03CC	Upper Middle Crooked Creek	12	1	8%
TMDL04CC	Upper Crooked Creek	12	1	8%
TMDL05CC	UT to Crooked Creek below TMDL02CC	12	3	25%

Fecal Coliform data were also collected by The Nature Conservancy in August 2004 (Table 3, Figure 6). These data indicate a definite influx of pathogens into Brush and Crooked Creek. However, these data were not used in the TMDL analysis because Kentucky does not yet have a reliable conversion ratio of fecal coliform to *E. coli*. The acute fecal coliform criterion for Kentucky is 400 colonies per 100 milliliter.

Table 4. Nature Conservancy pathogen data collected in August 2004.

Stream	Site Description	Latitude	Longitude	Fecal Coliform/ 100ml
Brush Creek				
BC-01	Rd Mile Marker 7.0 – above gravel rd	37.4619	-84.2299	50
BC-02	Rd Mile Marker – 6.5 Climax Spring Water	37.4605	-84.2297	700
BC-03	Rd Mile Marker – 5.5 1797 Bridge	37.4288	-84.2410	2300
BC-04	Rd Mile Marker – 2.9 Bridge	37.3982	-84.2643	1000
Crooked Creek				
CC-01	Bridge at Big Spring off 1797	37.3750	-84.2061	2100
CC-02	Boat Dock Spring	37.3684	-84.2120	400
CC-03	1797 Bridge	37.3679	-84.2120	300

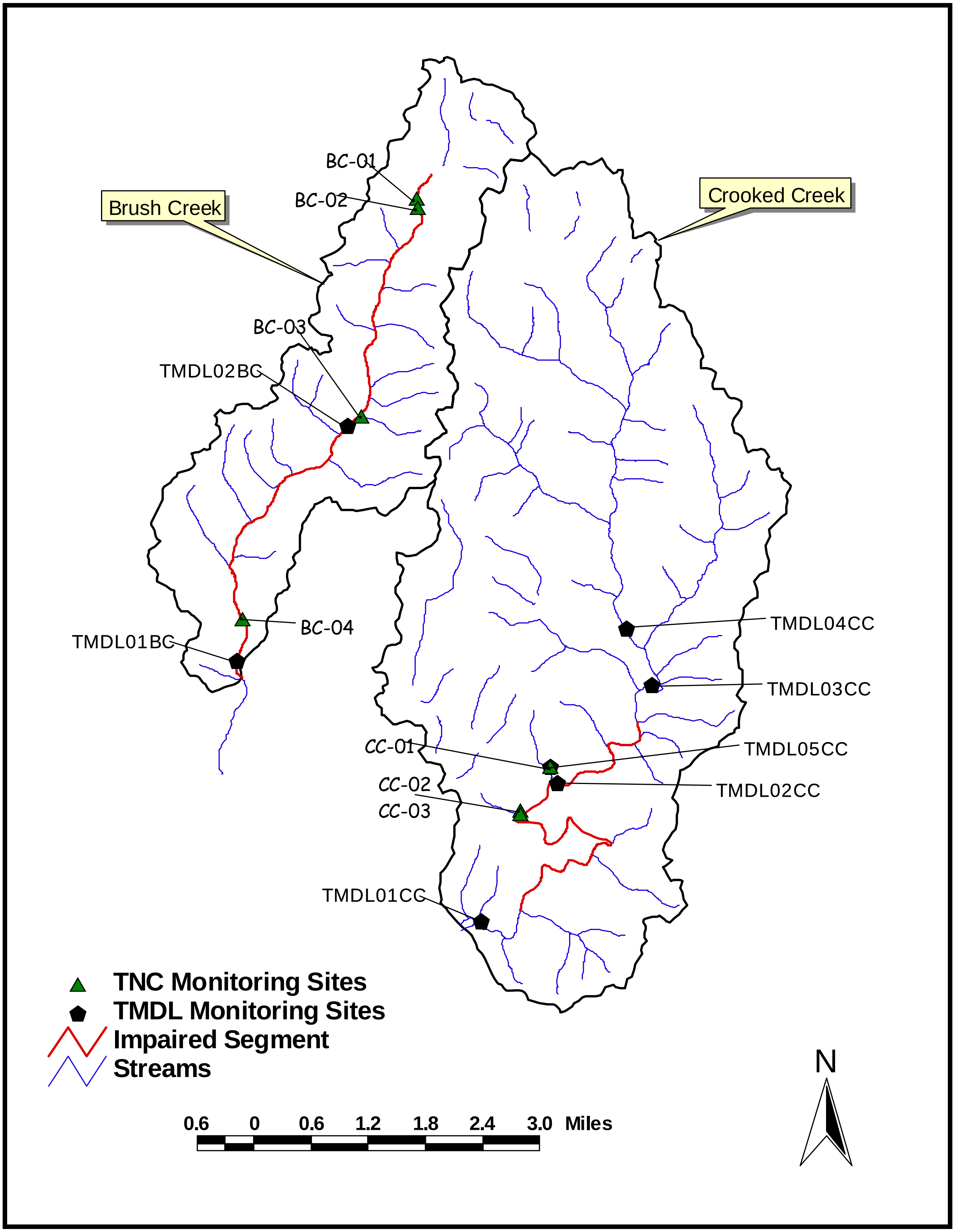

Figure 6. Map of The Nature Conservancy Monitoring Sites in Brush and Crooked Creek in Relation to the TMDL Monitoring Sites.

4.0 Source Assessment

4.1 Permitted Sources

Permitted sources include all sources regulated by the Kentucky Pollutant Discharge Elimination System (KPDES) permitting program. KPDES specifically regulates point sources, and according to 401 KAR 5:002, a point source is "any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, or concentrated animal feeding operation [CAFO], from which pollutants are or may be discharged. The term does not include agricultural storm water run-off or return flows from irrigated agriculture."

4.2 Non-permitted Sources

Non-permitted sources include nonpoint sources. According to 401 KAR 5:002, nonpoint means "any source of pollutants not defined as a point source, as used in this chapter." While nonpoint sources are legal and no permits are required, their loads to surface water are still regulated by laws such as the Kentucky Agricultural Water Quality Act and the federal Clean Water Act (i.e., the TMDL process), among others. Unlike point sources, nonpoint sources typically discharge pollutants to surface water in response to rain events. Nonpoint sources for pathogens exist in the watershed, and fall into various categories including agriculture, impacts directly attributable to humans (i.e., septic systems), household pets and natural background, which in the case of pathogens in a rural watershed means wildlife. These nonpoint sources are correlated to landuse.

A type of non-permitted source that may exist in the Cane Creek watershed is straight pipes, which are discrete conveyances that discharge sewage, gray water (i.e., water from household sinks, laundry, etc.) and stormwater to the surface waters of the Commonwealth without treatment. Although straight pipes meet the definition of a point source as defined in 401 KAR 5:002, EPA considers them to be a nonpoint source for load allocation purposes within a TMDL. Straight pipes are illegal, as are discharges from failing septic systems.

4.3 Agriculture

The Brush Creek watershed contains a minimal amount of agriculture. Steep slopes prevent row cropping. There are around 844 acres of open area suitable for pasturing cattle. These areas are mostly found on flat ridge tops and in the broad karst terrain found in the upper portion of the watershed. Based on the 2002 USDA Agriculture Census there are approximately 18,000 cows in Rockcastle County (USDA 2004).

Crooked Creek also has a minimal amount of agricultural activity. It also contains steep slopes unsuitable for large scale row cropping. There are some flat ridge tops and broad karst valleys suitable for pasturing cattle.

4.4 Human Waste Disposal

The potential sources of anthropogenic pathogens in Brush and Crooked Creek are failing/inadequate septic systems and straight pipes. There are approximately 100 houses in the Brush Creek watershed counted from the USGS 7.5 minute Wildie and Johnetta topographic maps and 1997 DOQ aerial photography. Assuming that each home is occupied and using the

2000 Census estimate of 2.5 persons per household in Rockcastle County there are approximately 260 people living in Brush Creek.

There are approximately 115 houses in the Crooked Creek watershed as counted from the USGS 7.5 minute topographic maps and 1997 DOQ aerial photography. Using the same persons per household assumption there are approximately 288 residents in the Crooked Creek watershed.

There are several factors that could potentially lead to *E. coli* loading from human sources in these watersheds. First, the area is not serviced by a sewer system. Second, the soils are not suitable for septic tanks due to poor drainage and thin soil depth (USDA 1981). Third, the area is underlain by karst terrain which could lead to short circuiting effluent from the leach fields directly to streams. Fourth, there may be straight pipe discharges to the streams. However, as stated in section 4.2 these are illegal discharges.

4.5 Household Pets

There are also likely to be domesticated animals (cats, dogs, etc) in both watersheds. The potential exists for *E. coli* to build up during dry periods and wash off into streams during runoff events. However, this is probably an insignificant portion of the total E. coli load in these watersheds.

4.6 Wildlife

With such a large portion of both watersheds being forested, wildlife is likely to be abundant. The Kentucky Department for Fish and Wildlife Resources estimates there are 2,457 deer in Rockcastle County (D. Yancy, personal comm.). This equates to approximately 8 deer per square mile or populations of about 76 and 192 in Brush and Crooked Creek, respectively. The KDFWR does not have population estimates for other wildlife species.

5.0 Data Analysis

The analytical approach used to develop the TMDLs for Brush and Crooked Creek was the load duration curve (LDC). A LDC is a data analysis tool that incorporates the hydrology as well as the concentration (number of *E. coli* colonies/100 ml) to develop existing and allowable loadings for TMDL development. It is also a graphical representation of the TMDL. The TMDL is represented by a continuous curve and the observed loads are usually point data. Points that plot above the curve are exceeding the TMDL and points below are within the TMDL limits. Loads are calculated using the following equation (equation 1):

Load = Concentration * Flow * Conversion Factor (Equation 1)

Where: Load = billions of colonies/day (BoC/day)
Concentration = colonies/100 ml
Discharge = cubic feet/ second (cfs)
Conversion Factor = (28.247L/cf * 86400sec/day * 1000ml/L)/ (100ml *1 billion colonies)

5.1 Flow Duration Curve

Before a LDC can be developed a flow duration curve (FDC) must be constructed. A FDC is the graphical display of cumulative frequency distribution of daily flow data. This curve relates the measured discharge at a given site to the percentage of time the measured flow is exceeded (Fig 7). The highest discharge events are plotted on the left side of the curve (since the highest flows are rarely exceeded), while the lowest flows are on the right side (since they are often exceeded). To construct an accurate FDC a long period of flow data is required. There was no such data set available for either Brush or Crooked Creek. The USGS operates a long term gaging station on the Rockcastle River at Billows (USGS gage 03406500). Flow data were collected at this gage from 07/15/1936 to 09/30/2005. Since the TMDL target (which is the Water Quality Criterion of 240 cfu/100 ml) and sampling was based on the Primary Contact Recreation designated use (which applies during the May – October summer recreational season), only flow data collected between May and October were used in the development of the FDC. In order to relate the flows at the USGS gage to the sampling points in the watersheds the area weighting method was used. Flows were multiplied by a ratio of the drainage area at the sampling point to the drainage area at the gage (equation 2) resulting in the area-weighted flow (AWF). The flow values represented at each flow duration interval may be found in the appendices.

AWF = Flow * (Area at Sample Site/Area at Rockcastle at Billows) (Equation 2)

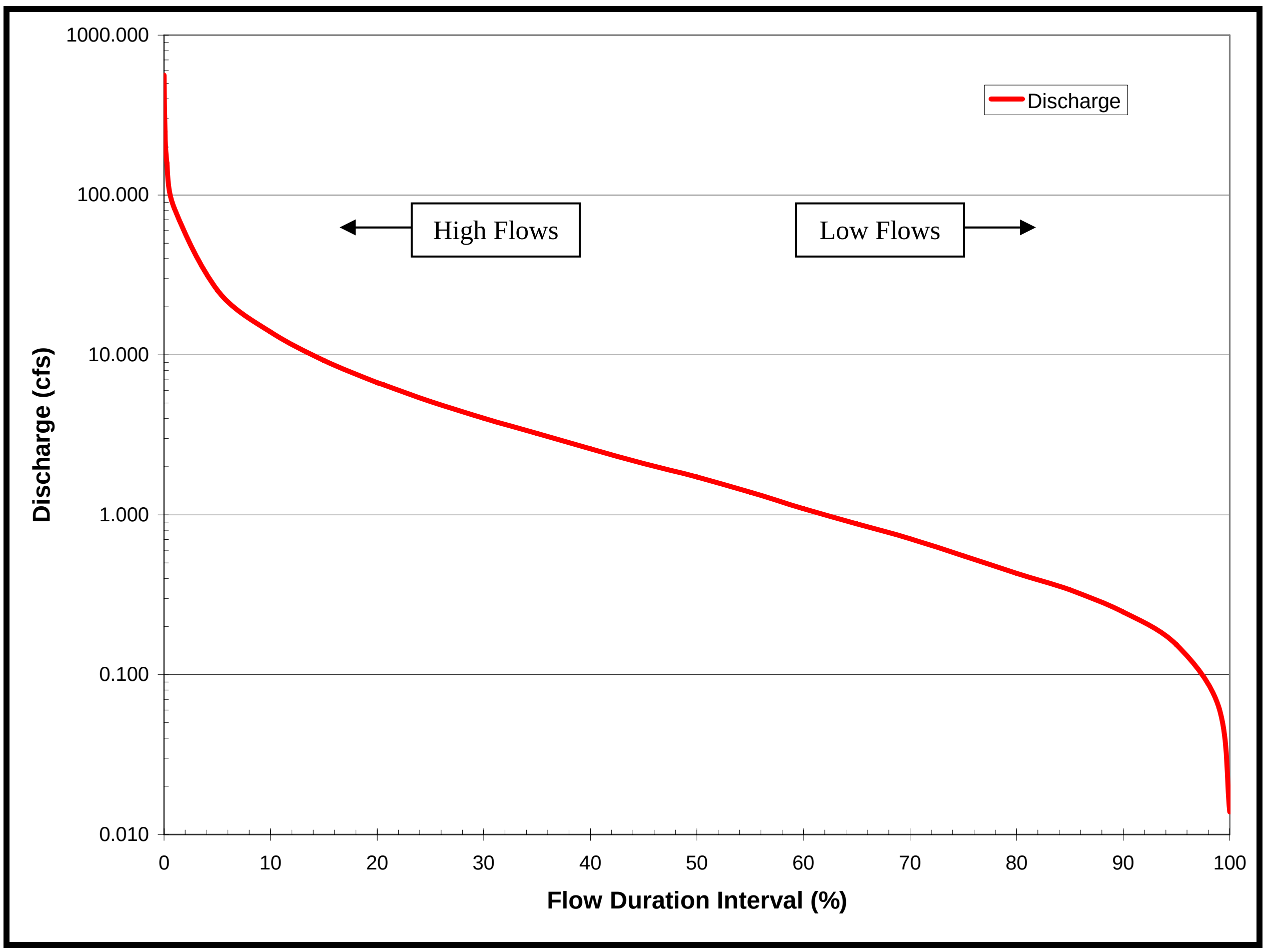

Figure 7. Example of a Flow Duration Curve

5.2 Load Duration Curve

To construct the Load Duration Curve the discharge values from the flow duration curve intervals are multiplied by the WQC for *E. coli* (240 colonies/100ml, see Equation 1). The acute criterion for *E. coli* was used because there was not sufficient data collected in Brush and Crooked Creek to calculate geometric means to compare to the chronic criterion (130 colonies/100 ml as a geometric mean). This line is the TMDL and represents the allowable loading at that particular flow duration interval. The existing loads are calculated using the instream concentration and flow observed during the 2005 recreational season by the KDOW. Observed values are converted into loads using equation 2 and plotted against the curve. Values that exceed the WQC will plot above the curve (Figure 7). The data used to calculate load duration curves at each site may be found in the appendices.

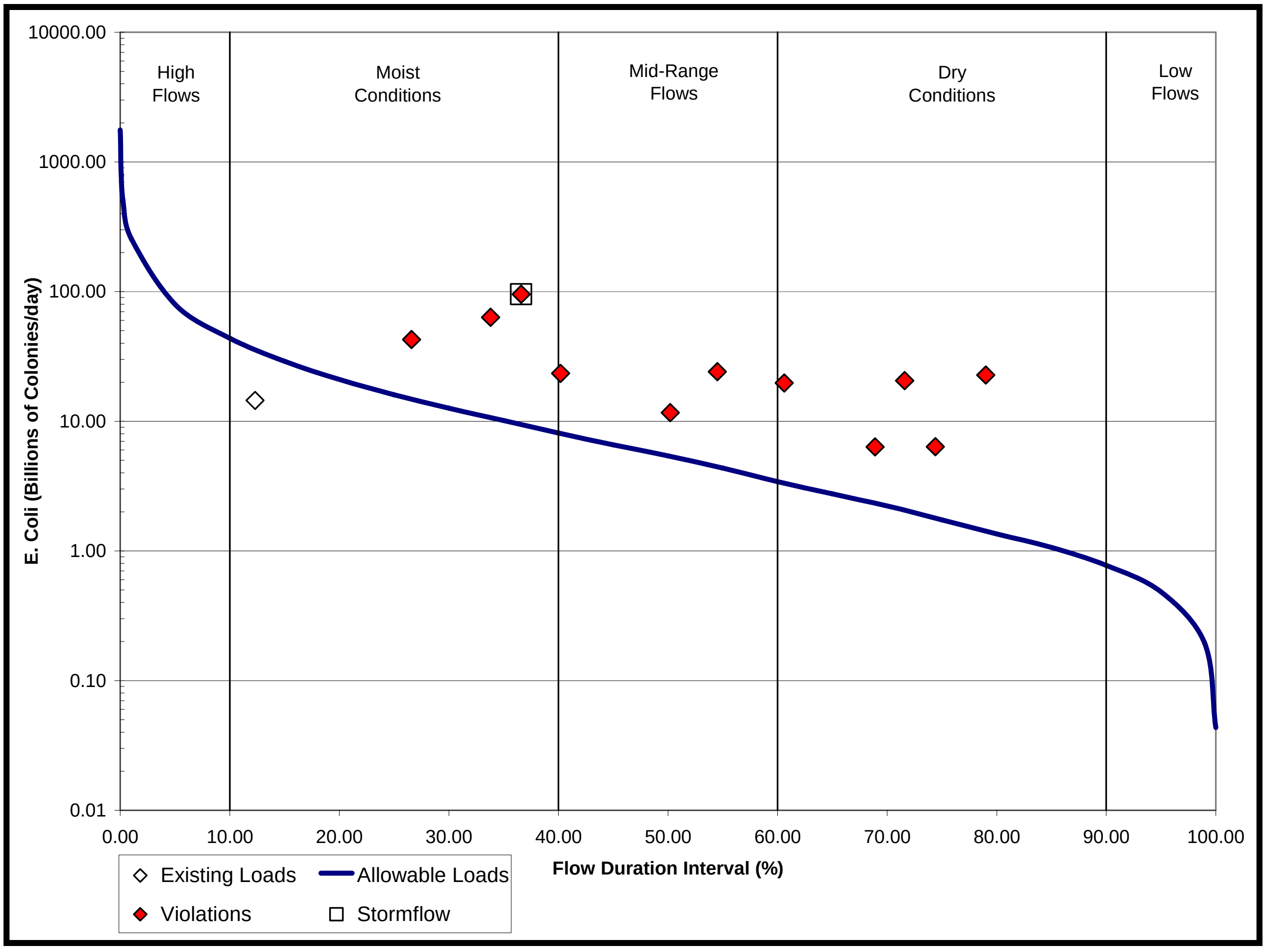

Figure 8. Example Load Duration Curve

There are many strengths of the LDC method. The method can accurately and easily relay information on the allowable and existing loads. It can be used to graphically determine the critical period based on flow conditions. The curve can be divided into flow zones (High, Moist, Mid-Range, Dry and Low). The critical period can be defined as the flow zone where the most violations of the WQC occur or if violations are distributed equally among the zones, the highest deviation from the curve can be considered the critical period. The LDC also allows for the inference of sources of the pollutant. For example, loads that exceed the allowable value in the moist load duration zone would most likely be the result of overland runoff and BMPs (Best Management Practices) can be focused on remediating the overland flow. Likewise, if the exceeding loads were observed in the dry flow duration zone then point source discharges, straight pipes and cattle wading in the streams would be candidate sources of bacteria pollution.

5.3 Uncertainty Analysis

Since there were no long term records of stream discharge on either Brush or Crooked Creek, the Rockcastle River at Billows, KY (USGS Gauge #03406500 1936-2005) was used to determine discharge in the TMDL watersheds. The area weighted method was applied to the discharge values to approximate the discharge values. This gage correlated very well to discharge measured in Brush and Crooked Creek in 2005 (R^2=0.9668 with Brush Creek and R^2=0.9947 with Crooked Creek see Appendix A). Although the Rockcastle River streamflow correlates well with the samples collected from Brush and Crooked Creek, the disparity between the sizes of watershed drained presents a problem in describing the low flow conditions for the smaller watersheds. The gaging station on the Rockcastle River has a 604 mi^2 watershed, while Brush and Crooked Creek are 9.56 mi^2 and 21.8 mi^2, respectively. These smaller watersheds will certainly run dry especially in the headwater tributaries. The Rockcastle River, by contrast, has not recorded a single dry day in over 69 years of record (1936 to present). The possible result of the size discrepancies is a shift of the FDC to the right and masking of periods of zero streamflow. Additionally, difficulties may be further magnified due to the karst terrain in the Roundstone Creek watershed. These issues increase the uncertainty in the calculations of the LDC, which is one reason an explicit 10% Margin of Safety (MOS) was used in the final load allocation, see Section 6.2.3.

6.0 Total Maximum Daily Load

6.1 TMDL Equation

A TMDL calculation is performed as follows:

$$\mathbf{TMDL = WLA + LA + MOS} \qquad \text{(Equation 2)}$$

Where:

TMDL = the TMDL target, which was defined in Section 5.1 as the loading that is equivalent to a concentration of 240 colonies/100 ml at a given flow, in units of billions of colonies per day.

WLA = the WasteLoad Allocation, including point sources and other permitted sources such as Municipal Separate Storm Sewer Systems (MS4s). As stated, no point sources exist in these watersheds.

LA = the Load Allocation, including nonpoint sources and natural background.

MOS = the Margin Of Safety, which can be an implicit or explicit additional reduction applied to the WLA, LA or both types of sources that accounts for uncertainties in the data or TMDL calculations.

For purposes of implementing the TMDL a TMDL Target Load is calculated using the following equation (Equation 3). The TMDL Target Load will be apportioned to the WLA (if any exist) and LA. Permit restrictions and Best Management Practices will be applied until the WQS is met. The TMDL calculation must take into account seasonality and other factors that affect the relationship between pollutant inputs and the ability of the stream to meet its designated uses.

TMDL Target Load = TMDL – MOS (Equation 3)

6.2 TMDL Components

6.2.1 Critical Conditions

At each station, the critical period (which in this case will be defined as a flow condition) was selected based on the magnitude and frequency of the observed exceedances of the TMDL target load.

6.2.2 Waste Load Allocation and Load Allocation

As stated, there are no known permitted point sources in these watersheds, so no loading was applied to the WLA portion of the TMDL calculation. Therefore all reductions will be nonpoint source reductions, and attributed to the LA portion of the TMDL calculation. Any future permitted point sources in these watersheds must meet permit limits and must not cause or contribute to an existing impairment.

The LDC was divided into five zones based on the flow duration interval; high flow, moist, mid-range flow, low flow and dry conditions. If there were three or more exceedances in a given zone the 90^{th} percentile of the mean was calculated. This value was used to determine the existing load of *E. coli* to the stream at that sampling station. Where fewer than three observations exceeded the WQC, the highest exceedance was used to calculate existing load for that station. The critical condition was thus defined as the portion of the LDC with the highest exceedance of the allowable load. Load allocations will be calculated for each flow regime on the LDC. Percent reductions will be calculated using equation 3.

$$[(\text{Existing Load} - \underbrace{(\text{TMDL Load} - \overbrace{(\text{TMDL Load} * 0.1))}^{\text{Term = MOS}}}_{\text{Term = LA}}/\text{Existing Load}] *100 \qquad \text{(Equation 3)}$$

6.2.3 Margin of Safety

Using either the maximum exceedance or the 90^{th} percentile to determine the percent reduction will result in an implicit margin of safety, since such a comparatively large reduction means all other sample data will be in compliance once the necessary reduction is achieved. However, this is balanced to a degree by using proportional area flows from a gaged stream which goes dry less often than the streams in the TMDL watershed. Therefore, an explicit margin of safety of 10% will be applied to the final reductions at all stations.

6.3 TMDL Summary for Brush Creek

There were a total of 21 *E. coli* samples collected from two sites in Brush Creek (Figure 2). There were violations of the WQC in 11% (Appendix B1) of the samples collected at the lower site and 92% (Appendix B2) of the samples collected from the upper site. This indicates that the majority of the *E. coli* load is being produced in the upper portion of the watershed. This is also supported by the Nature Conservancy fecal coliform data collected in August 2004 (Table 4).

In the upper portion of the watershed the violations occurred over three of the flow duration zones; Moist, Mid-Range and Dry (Table 5). This indicates that E coli are likely entering the stream as runoff from overland flow and direct deposition. The critical flow condition was determined as the 65% flow duration interval, which falls in the Dry Conditions zone (Table 5). The observed load at this flow condition was 21.85 BoC/day with a TMDL target load of 2.95 BoC/day. After applying a 10% margin of safety (MOS), the load reduction necessary to meet the WQC is 88%.

The lower site in the watershed had only one violation of the WQC in the 2005 sampling season Appendix B1). This occurred after a significant rainfall (Appendix A2). The observed load used for the final TMDL calculation occurred at a flow duration interval of 36%, which lies in the Moist Zone (Table 5). The TMDL target load is 16.17 BoC/day and after applying the 10% MOS a load allocation of 14.55 BoC/day was assigned to the lower Brush Creek site. The observed load of 105.86 BoC/day requires an 85% reduction in *E. coli* loading to meet the TMDL requirements (Table 4). The sampling is unable to definitively determine whether this violation was due to runoff within the subwatershed or the result of *E. coli* loading from the upper subwatershed. There were no samples collected from this site during the 07/21/2005, 07/27/2005 and 08/03/2005 sampling trip due to a beaver dam downstream of the sampling location that altered the flow conditions. The beaver dam was no longer present during the final two sampling events (09/07/2005 & 10/04/2005), therefore sampling from this location resumed.

Table 5. Summary of Existing and Allowable Loads in Brush Creek by Flow Duration Zone.

	Flow Duration Zone	Existing Conditions		TMDL = WLA +LA + MOS				TMDL Target Load (BoC/Day)[1]	Reduction (percent)
		WLA (BoC/Day)[1]	LA (BoC/Day)[1]	TMDL (BoC/Day)[1]	WLA (BoC/Day)[1]	LA (BoC/Day)[1]	MOS (BoC/Day)[1]		
TMDL01BC Lower Brush Creek	High	0	N/A[2]	2386.86	0[3]	2148.16	238.7	2148.16	N/A[2]
	Moist	0	105.86	16.17	0[3]	14.55	1.62	14.55	85%
	Mid-Range	0	N/A[2]	14.03	0[3]	12.63	1.4	12.63	N/A[2]
	Dry	0	N/A[2]	5.66	0[3]	5.09	0.57	5.09	N/A[2]
	Low	0	N/A[2]	1.28	0[3]	1.15	0.13	1.15	N/A[2]
TMDL02BC Upper Brush Creek	High	0	N/A[2]	1275.56	0[3]	1148	127.56	1148	N/A[2]
	Moist	0	88.92	14.08	0[3]	12.67	1.41	12.67	86%
	Mid-Range	0	23.95	7.61	0[3]	6.85	0.76	6.85	71%
	Dry	0	21.85	2.95	0[3]	2.65	0.3	2.65	88%
	Low		N/A[2]	0.69	0[3]	0.62	0.07	0.62	N/A[2]

Notes:
1. BoC/Day = Billions of Colonies E. coli per day
2. N/A = No sample collected in this flow zone exceeds the Water Quality Criterion. Therefore the percent reduction is unknown
3. Any future permitted point source must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment
4. No load reduction calculated because <10% of samples violated WQC.
5. The critical flow condition is highlighted

6.4 TMDL Summary for Crooked Creek

There were a total of 60 E coli samples collected from five sites in Crooked Creek. There were violations of the WQC in a total of 18% of the samples. Each subwatershed had at least one sample that violated the WQC and the lower watershed had the most violations (4 of 12) (Appendix B3-B7). The results of sampling do not appear as easily discernable as in Brush Creek. However, the data show the UT to Crooked Creek (TMDL05CC) and the lower subwatershed (TMDL01CC) to be the more critical source areas to address.

In the upper portion of the watershed (subwatershed TMDL04CC) there was only one violation of the WQC during the Mid-Range Flow Zone (Appendix B6 and Table 6). The observed loading was determined at 11.6 BoC/day and the TMDL target load was 9.04 BoC/day. With a 10% margin of safety the load allocation for this subwatershed was 8.14 BoC/day. Since less than ten percent (10%) of the samples collected were lower than the WQC, there was no reduction calculated for this site (Table 6; see section 3.0 for explanation of 10% rule of thumb).

There was one violation in the upper middle subwatershed (TMDL03CC) (Appendix B.5). The TMDL target load for this watershed during the critical flow condition (8% flow duration interval, which is in the High Flows zone, Table 6) was 136.81 BoC/day. After applying the 10% margin of safety the load allocation was 123.13 BoC/day. Since less than ten percent (10%) of the samples collected were lower than the WQC, there was no reduction calculated for this site (Table 6; see section 3.0 for explanation of 10% rule of thumb).

The lower middle Crooked Creek subwatershed (TMDL02CC) had one sample out of twelve (8%) that exceeded the WQC (Appendix B4). This occurred in the Mid-Range flow duration zone. The TMDL target for this subwatershed was 19.73 and the load allocation (after applying the 10% MOS) was 17.76 (Table 6). Since less than ten percent (10%) of the samples collected were lower than the WQC, there was no reduction calculated for this site (Table 6; see section 3.0 for explanation of 10% rule of thumb).

One tributary watershed (TMDL05CC) that discharges into Crooked Creek just below the TMDL02CC sample site (Figure 3) was of particular interest. The drainage area is 3.17 mi2, but the stream network consists of several sinking streams. The portion that discharges to Crooked Creek exits a cave about 850 feet from the confluence with Crooked Creek. There were three samples of this karst tributary that exceeded the WQC; one each in the moist, mid-range and dry flow duration zone (Appendix B7 and Table 6). Additionally, the Nature Conservancy reported elevated fecal coliform from this tributary during August 2004 (Table 3). The TMDL target load for this subwatershed is 5.52 BoC/day. The highest observed load was 71.29 BoC/day. In order to meet the load allocation of 4.97 BoC/day the loading will need to be reduced by 93% (Table 6).

The lower site in the watershed (TMDL01CC) had four samples that violated the WQC (Appendix B3); one in the moist zone, two in the mid-range zone and one in the dry flow duration zone (Table 6). The load allocation of 41.62 BoC/day requires a 91% reduction from the observed load of 416.31 BoC/day. This reduction will meet the TMDL target load of 14.55 BoC/day (Table 6).

Table 6. Summary of Existing and Allowable Loads in Crooked Creek by Flow Duration Zone

	Flow Duration Zone	Existing Conditions WLA (BoC/Day)[1]	Existing Conditions LA (BoC/Day)[1]	TMDL = WLA +LA + MOS: TMDL (BoC/Day)[1]	WLA (BoC/Day)[1]	LA (BoC/Day)[1]	MOS (BoC/Day)[1]	TMDL Target Load (BoC/Day)[1]	Reduction (percent)
TMDL01CC Lower Crooked Creek	High	0	N/A[2]	5595.01	0[3]	5035.51	559.50	5035.51	N/A[2]
	Moist	0	416.31	41.62	0[3]	37.46	4.16	37.46	91%
	Mid-Range	0	144.85	33.23	0[3]	29.91	3.32	29.91	79%
	Dry	0	N/A[2]	10.10	0[3]	9.09	1.01	9.09	N/A[2]
	Low Flow	0	N/A[2]	3.01	0[3]	2.71	0.30	2.71	N/A[2]
TMDL02CC Lower Middle Crooked Creek	High	0	N/A[2]	4106.43	0[3]	3695.79	410.64	3695.79	N/A[2]
	Moist	0	N/A[2]	112.15	0[3]	100.93	11.21	100.93	N/A[2]
	Mid-Range	0	75.71	19.73	0[3]	17.76	1.97	17.76	**[4]
	Dry	0	N/A[2]	9.74	0[3]	8.76	0.97	8.76	N/A[2]
	Low Flow	0	N/A[2]	2.21	0[3]	1.99	0.22	1.99	N/A[2]
TMDL03CC Upper Middle Crooked Creek	High	0	465.17	136.81	0[3]	123.13	13.68	123.13	**[4]
	Moist	0	N/A[2]	86.21	0[3]	77.59	8.62	77.59	N/A[2]
	Mid-Range	0	N/A[2]	15.27	0[3]	13.74	1.53	13.74	N/A[2]
	Dry	0	N/A[2]	7.49	0[3]	6.74	0.75	6.74	N/A[2]
	Low Flow	0	N/A[2]	1.70	0[3]	1.53	0.17	1.53	N/A[2]
TMDL04CC Upper Crooked Creek	High	0	N/A[2]	2207.21	0[3]	1986.49	220.72	1986.49	N/A[2]
	Moist	0	N/A[2]	60.28	0[3]	54.25	6.03	54.25	N/A[2]
	Mid-Range	0	11.60	9.04	0[3]	8.14	0.90	8.14	**[4]
	Dry	0	N/A[2]	5.23	0[3]	4.71	0.52	4.71	N/A[2]
	Low Flow	0	N/A[2]	1.19	0[3]	1.07	0.12	1.07	N/A[2]
TMDL05CC UT to Crooked Creek	High	0	N/A[2]	813.59	0[3]	732.23	81.36	732.23	N/A[2]
	Moist	0	71.29	5.52	0[3]	4.97	0.55	4.97	93%
	Mid-Range	0	3.30	2.23	0[3]	2.01	0.22	2.01	42%
	Dry	0	3.19	1.76	0[3]	1.58	0.18	1.58	50%
	Low Flow	0	N/A[2]	0.44	0[3]	0.39	0.04	0.39	N/A[2]

Notes:
1. BoC/Day = Billions of Colonies E. coli per day
2. N/A = No sample collected in this flow zone exceeds the Water Quality Criterion. Therefore the percent reduction is unknown
3. Any future permitted point source must meet permit limits based on the Water Quality Standards in 401 KAR 5:031, and must not cause or contribute to an existing impairment
4. Less than 10% of the samples collected violated the WQC, therefore no load reduction was calculated.
5. The critical flow condition is highlighted

7.0 Implementation

7.1 Implementation

Section 303(e) of the Clean Water Act and 40 CFR Part 130, Section 130.5, require states to have a continuing planning process (CPP) composed of several parts specified in the Act and the regulation. The CPP provides an outline of agency programs and the available authority to address water issues. Under the CPP umbrella, the Watershed Management Branch will provide technical support and leadership with developing and implementing watershed plans to address water quality and quantity problems and threats. Developing watershed plans enables more effective targeting of limited restoration funds and resources, thus improving environmental benefit, protection and recovery.

The in-stream pathogen data used to develop the TMDLs for Brush and Crooked Creek do not allow loads to be quantitatively allocated to the different sources within the watershed. Therefore, no specific recommendations for remediation are offered until additional watershed planning is conducted. Development of a watershed plan will provide an integrative approach for identifying and describing what actions should be taken in order to meet water quality standards, how the actions will be accomplished, who will undertake the actions and when the actions will be completed. This TMDL will provide a foundation for developing a detailed watershed plan.

7.2 Ongoing Activities

7.2.1 PRIDE

Eastern Kentucky PRIDE (Personal Responsibility in a Desirable Environment) is a nonprofit organization funded by federal grants to encourage and assist citizens, local governments, schools and others in 38 counties of southern and eastern Kentucky to; improve the water, clean up illegal trash dumps and other solid waste problems, and promote environmental awareness and education. Eastern Kentucky PRIDE is funded by grants from the National Oceanic and Atmospheric Administration. The U.S. Environmental Protection Agency and U.S. Army Corps of Engineers also fund projects that support the PRIDE initiative.

One of the grant programs PRIDE has available is the Homeowner Septic System Grant. This program funds the replacement of straight pipes or failing septic systems with sanitary wastewater treatment systems that meet state and federal laws. As of August 31, 2005 PRIDE has invested more than $20 million in over 6000 septic systems across the region. (PRIDE 2006)

PRIDE has funded several septic systems in the Brush and Crooked Creek watersheds. Data obtained from the Rockcastle County Health Department are shown in Table 7 below (Patton 2006).

Table 7. Septic System Installation Data for Brush and Crooked Creek (Patton 2006)

Fiscal Year	Number of PRIDE	% of Total PRIDE	% of Total Systems	Number of other Systems	% of Total Systems	Total Systems in Area	% of Total Systems
1999/00	1[1]			1[1]		2[1]	0.7[1]
2000/01	2[1]			2[1]		4[1]	1.9[1]
2001/02	11	13.6	4.4	1[1]	0.4	12[1]	4.8
2002/03	19	27.5	7.9	9	3.8	28	11.7
2003/04	7	25.0	4.3	6	3.7	13	8.0
2004/05	4	17.4	3.0	8	5.9	12	8.9
2005/06				3[2]	4.1[2]		

Note: Each year listed represents the Fiscal Calendar starting July 1 and ending June 30 of the following year.

[1]Data incomplete, not easily retrieved.
[2]2005/06 – Year to date (February 2006)

7.2.2 Roundstone Renewal 319(h) Project

The Roundstone Renewal BMP Demonstration Project is a Clean Water Act Section 319(h) funded project to the Kentucky Division of Conservation (DOC). The project was designed to implement Best Management Practices that will address known impairments in the Roundstone Creek watershed. Foremost among these are sediment, nutrient and pesticide run-off. Through the development of a local grassroots watershed organization, the project will also promote consensus building among the stakeholders and inhabitants of the Roundstone Creek watershed.

The project will install agricultural BMPs on a minimum of eight high priority sites as identified by The Nature Conservancy (TNC), the lead agency for the project. The Natural Resources Conservation Service is designing the BMPs that are location-specific. Selections will include stabilization of streambanks through fencing cattle from the banks, riparian plantings of native cane, grasses and/or tree seedlings, application of #2 rock to eroding road surfaces, establishment of filter strips, improved stream crossings, fencing for planned grazing and development of alternative water sources for cattle. The project will install BMPs on a minimum of eight locations prior to the end of the grant period in December of 2007.

In order to demonstrate the effectiveness of the selected BMP, there will be at least one field day at each of the high priority sites. Interested parties may obtain advance notice of these field days through newspapers and landowners in the area. TNC is providing pre-implementation and post-implementation photo documentation of the sites and will conduct site visits to evaluate the effectiveness of the BMPs.

Although there is no direct implementation in either Brush or Crooked Creek both drain to Roundstone Creek. There is hope that the outreach will effect changes in the current TMDL watersheds. For information on this organization, contact Jim Hays at jhays54@yahoo.com.

8.0 References

ESRI, 2000. ArcView GIS 3.2a. Environmental Systems Research Institute, Redlands, CA.

Homer, C., C. Huang, L. Yang, B. Wylie and M. Coan. 2004. Development of a 2001 National Land-Cover Database for the United States. Photrgrammetric Engineering & Remote Sensing. Vol. 70 No. 7: 829-840.

Kentucky Natural Resources and Environmental Cabinet, 1998. 1998 303(d) List of Waters for Kentucky. Kentucky Department for Environmental Protection, Division of Water, Frankfort, KY June 1998.

Patton, C. 2006 Personal Communication. Rockcastle County Health Department. February 2006.

PRIDE. 2006. http://www.kypride.org/. Web Site Accessed March 7, 2006.

Ray, J.A., J.S. Webb and P.W. O'Dell. 1994. Groundwater Sensitivity Regions of Kentucky (color poster with map, descriptive text and tables). Kentucky Natural Resources and Environmental Protection Cabinet (map scale 1:50000).

Sloto, R.A., and Crouse, M.Y., 1996, HYSEP: A computer program for streamflow hydrograph separation and analysis: U.S. Geological Survey Water-Resources Investigations Report 96-4040, 46 p

United States Department of Agriculture. 1981. Soil Survey of Laurel and Rockcastle Counties, Kentucky. 98pp. illus.

United States Department of Agriculture. 2004. 2002 Census of Agriculture, Volume 1, Geographic Area Series Part 17, U.S. Department of Agriculture, National Agricultural Statistics Service. AC02-A-17, June 2004.

United States Environmental Protection Agency. 2004. Analytical Tools Interface for Landscape Assessments (ATtILA) User Manual. EPA/600/R-04/083.

United States Geological Survey. 2001. National Land Cover Database. http://www.mrlc.gov.

Woods, A.J., Omernik, J.M., Martin, W.H., Pond, G.J., Andrews, W.M., Call, S.M,Comstock, J.A., and Taylor, D.D., 2002, Ecoregions of Kentucky (color poster with map, descriptive text, summary tables, and photographs): Reston, VA., U.S. Geological Survey (map scale 1:1,000,000).

Yancy, D.L. 2006. Personal Communication. Kentucky Department of Fish and Wildlife Resources. February 2006.

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Appendix A. Data Analysis Report

A.1 Use of Proportional Area Flow

As stated in Section 5.0, Data Analysis, flow data from the USGS Rockcastle River gage at Billows was used to generate the flow data used in these TMDLs for the Brush and Crooked Creek watersheds. Below are the correlations between flows taken in the Brush Creek watershed at station 1 and the nearby Rockcastle River gage, (03406500). As stated, the proximity, lack of flow control and high correlation of the Rockcastle River to Brush (Figure 8) and Crooked Creek (Figure 9) made it the best choice for comparison.

Only published data from the USGS were used to generate the flow and load duration curves used in this TMDL. The period of record for the Rockcastle River gage was from 07/15/1936 to 09/30/2004, a period which was more than sufficient to smooth out the effects of extreme wet and dry years without the inclusion of the provisional data (which includes the data from 10/1/04 forward). However, provisional data were needed for comparison of concurrent flows.

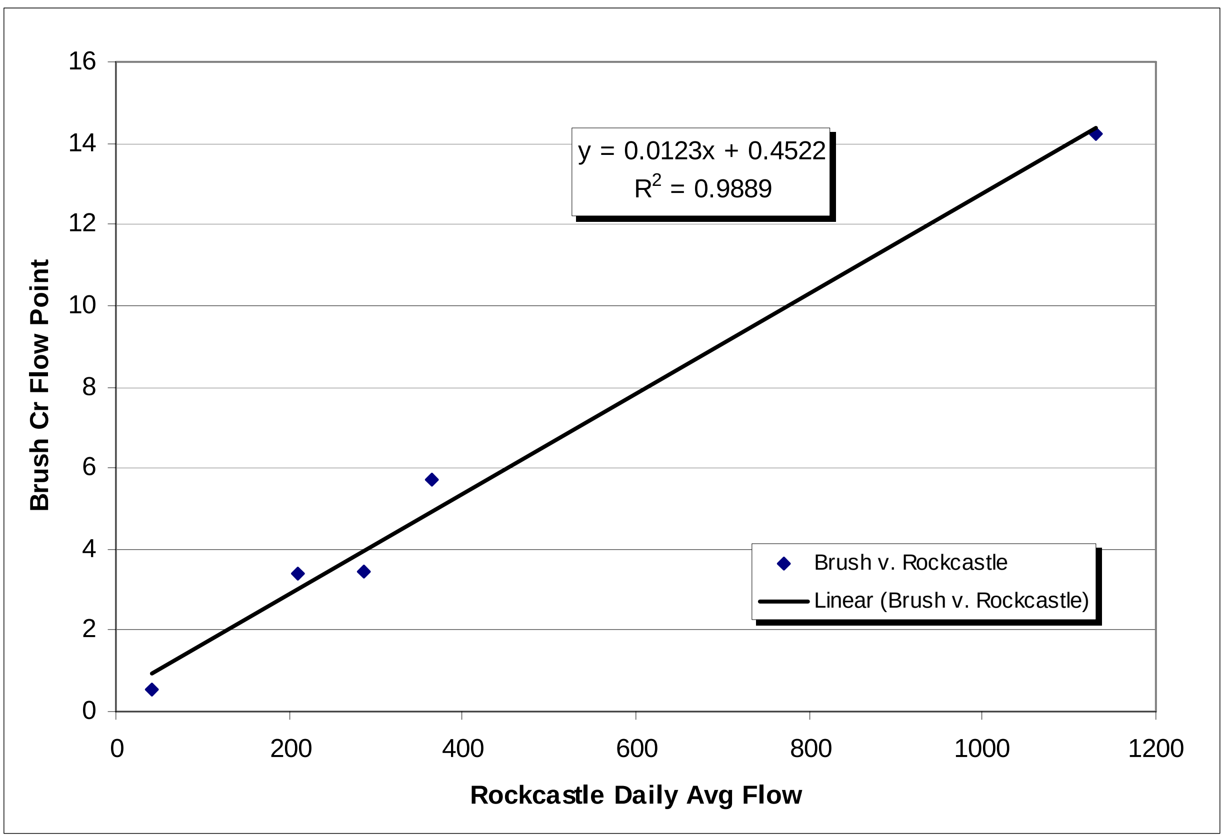

Figure 9. Correlation Between Concurrent Flow at Brush Creek and Rockcastle River, Billows, KY

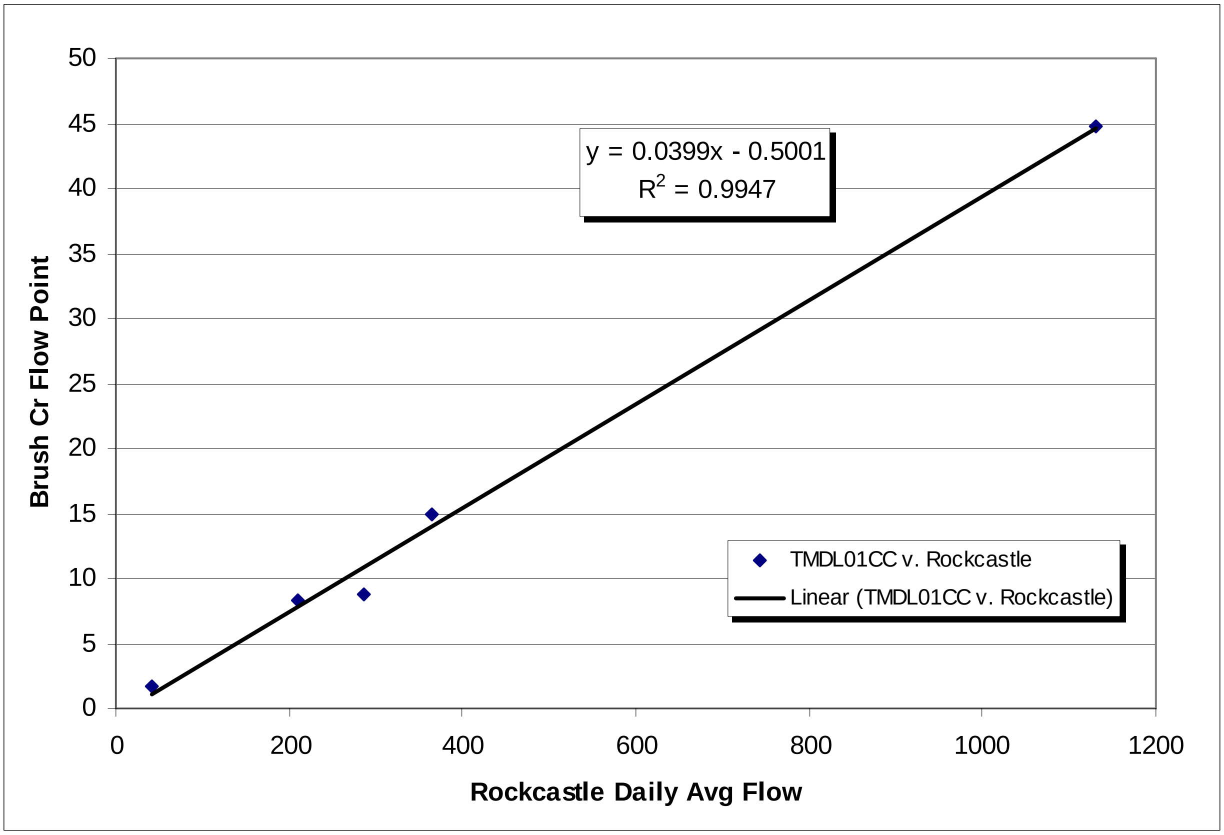

Figure 10. Correlation of Concurrent Flow at Brush Creek and Rockcastle River, Billows, KY.

A.2 Stormflow

In watersheds where the majority of pollutant sources are nonpoint source it is useful to determine if any samples were observed during the runoff portion of the hydrograph. To determine whether a sample is taken during the runoff portion of a storm hydrograph, the percent stormflow was calculated using the Hydrograph Separation (or HYSEP) method developed by USGS (1996). HYSEP includes different mathematical protocols to separate baseflow from stormflow on a given day, and KDOW used the Sliding Interval approach, see USGS (1996) for further discussion. After subtracting baseflow, HYSEP determines the flow on a given day compared to the lowest flow in a 5-day period around that day, and if this change is greater than 50%, the sample taken on that day is considered to be from the runoff portion of a storm's hydrograph. For each watershed only one sample occurred during a stormflow event (July 13).

Additionally, precipitation data collected at the USGS Rockcastle River gage was compared to the sample events. This data is only an approximation since the Rockcastle River gage is more than 20 miles away from some areas of Brush and Crooked Creek. However, the information gained is still useful. Note that the only event classified as a stormflow event based on the HYSEP method occurred after consecutive days of precipitation (Figures 10 and 11). There were violations of the water quality criterion at 6 of 7 stations.

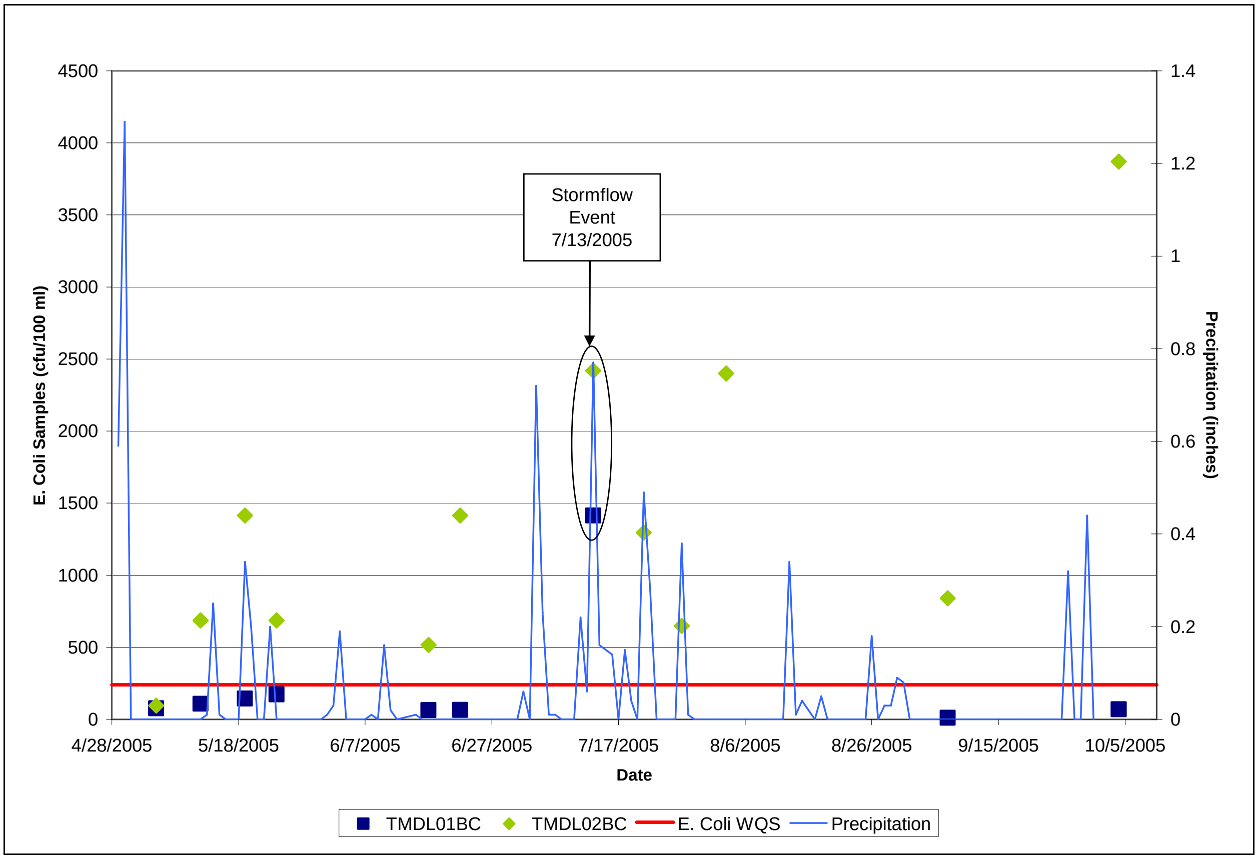

Figure 11. Comparison of E. coli concentrations observed in Brush Creek and precipitation recorded at the Rockcastle River USGS gage at Billows, KY.

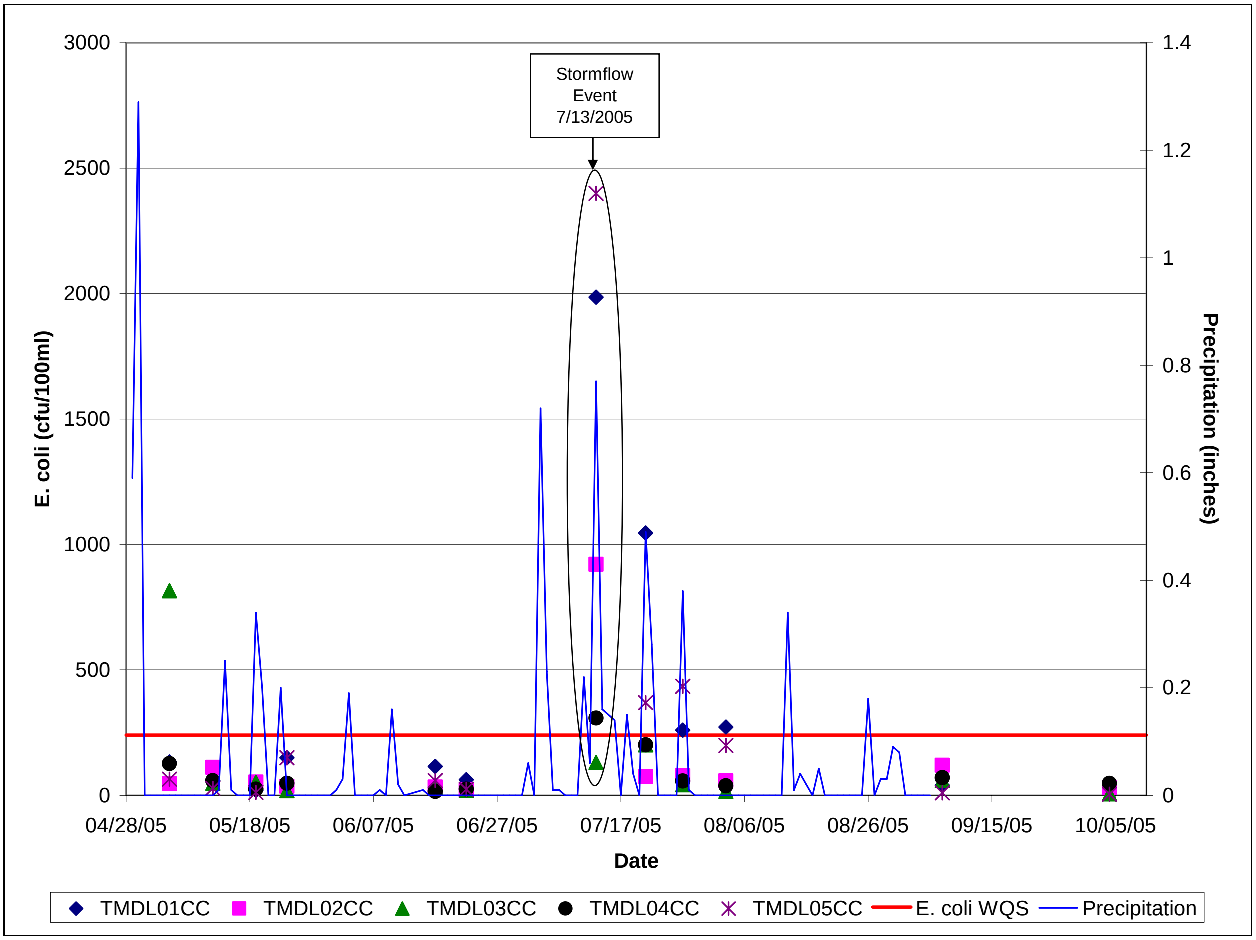

Figure 12. Comparison of E. coli concentrations observed in Brush Creek and precipitation recorded at the Rockcastle River USGS gage at Billows, KY.

A.3. Landuse Analysis

The land uses generated by the 2001 NLCD were amalgamated for presentation purposes within Section 3.3, specifically in Tables 2 and 3 of this report. All forested land (deciduous, evergreen and mixed) and shrubbery was aggregated and reported as one category. Also, all lands in the NLCD data reported as grassland/herbaceous were reported as pasture. Further, all residential landuse area was aggregated and reported as one category; developed land. The NLCD returned small but positive values for three types of residential landuses—Developed Open Space, Low-Intensity Residential, and High-Intensity Residential. Developed Open Space is a term applied to differing types of landuse, within urban areas it is the designation given to parkland and other green areas. However, in a rural watershed such as Cane Creek, it designates residential areas with insufficient density to be classified as Low-Intensity Residential (James Seay, 2006, Personal Communication) but is mainly composed of single family residences on large lots (Table 9).

Table 8. National Land-Cover Database Class Descriptions Taken from Homer et al 2004.

11. **Open Water** - All areas of open water, generally with less than 25% cover of vegetation or soil.

21. **Developed, Open Space** - Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes

22. **Developed, Low Intensity** - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49 percent of total cover. These areas most commonly include single-family housing units.

23. **Developed, Medium Intensity** - Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79 percent of the total cover. These areas most commonly include single-family housing units.

24**. Developed, High Intensity** - Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80 to100 percent of the total cover.

31. **Barren Land (Rock/Sand/Clay)** - Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.

41. **Deciduous Forest** - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species shed foliage simultaneously in response to seasonal change.

42. **Evergreen Forest** - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. **Mixed Forest** - Areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.

52. **Shrub/Scrub** - Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes true shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.

71. **Grassland/Herbaceous** - Areas dominated by grammanoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.

81. **Pasture/Hay** - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.

82. **Cultivated Crops** - Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20 percent of total vegetation. This class also includes all land being actively tilled.

90. **Woody Wetlands** - Areas where forest or shrubland vegetation accounts for greater than 20 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

95. **Emergent Herbaceous Wetlands** - Areas where perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

Appendix B. Data Report

B1 Lower Brush Creek Site (TMDL01BC)

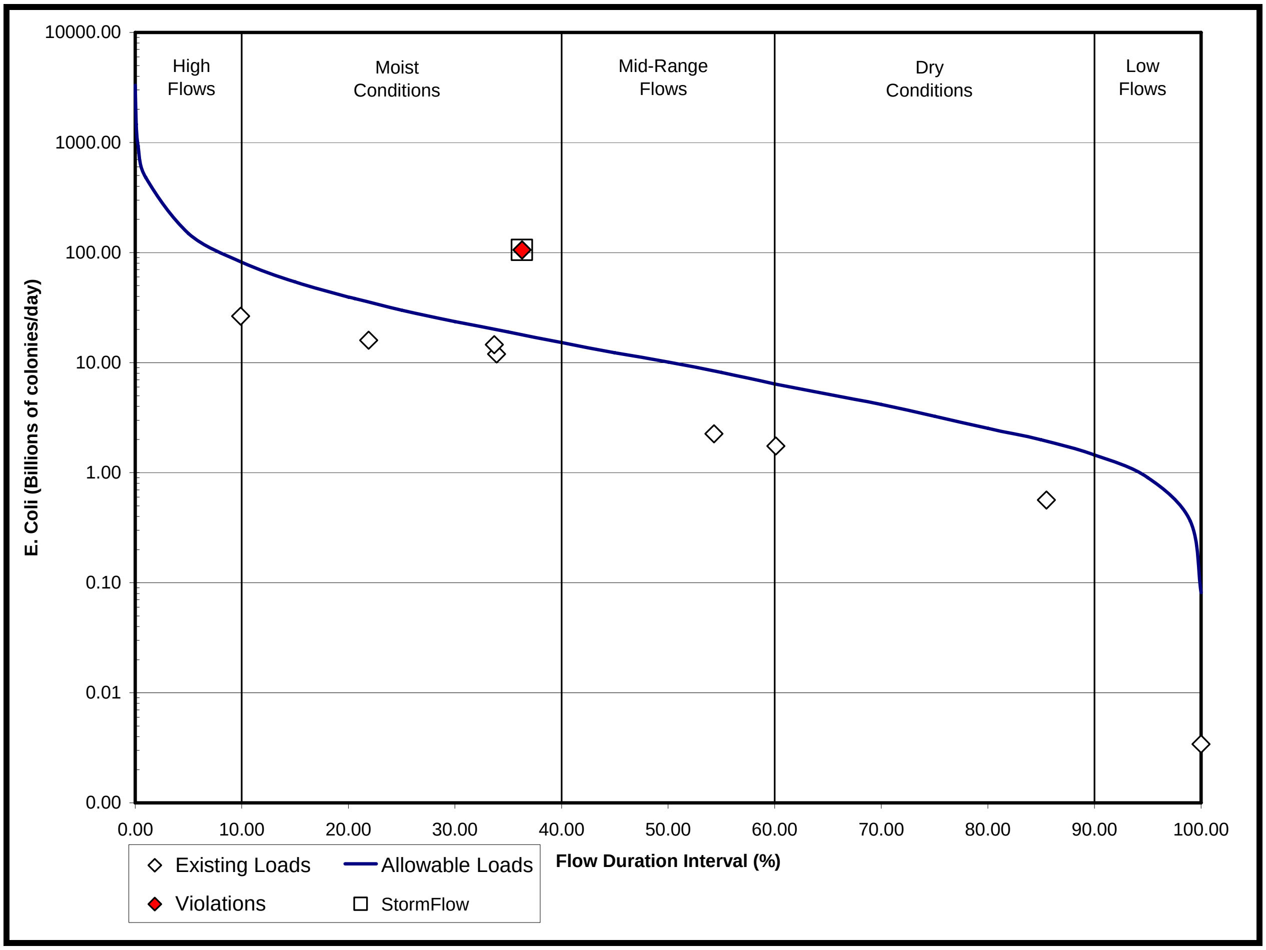

Figure 13. Load Duration Curve and TMDL for Lower Brush Creek, Site TMDL01BC

Table 9. Table of Data Used to Construct Load Duration Curve for Lower Brush Creek (TMDL01BC)

BRUSH CREEK TMDL01BC											
Percentile Rank	Area Weighted Flows	TMDL	LA	WLA	MOS		Date Collected	*E. Coli*	Measured Flow	Flow Percentile	Pollutant Load
0.007943	563.550	3309.06	2978.15	0.00	330.91		5/5/2005	76	14.23	9.90	26.46
0.1	249.440	1464.67	1318.20	0.00	146.47		5/12/2005	108	5.72	22.8	15.11
0.273973	158.624	931.41	838.27	0.00	93.14		5/19/2005	144	3.4	33.90	11.98
1	81.795	480.28	432.26	0.00	48.03		5/24/2005	173	3.44	33.70	14.56
5	25.406	149.18	134.26	0.00	14.92		6/17/2005	64	1.44	54.30	2.25
10	13.904	81.64	73.48	0.00	8.16		6/22/2005	65	1.1	60.10	1.75
15	9.233	54.22	48.79	0.00	5.42		7/13/2005	1414	3.06	36.30	105.86
20	6.698	39.33	35.40	0.00	3.93		9/7/2005	10	0.014	100.00	0.003
20.6	6.498	38.16	34.34	0.00	3.82		10/4/2005	70	0.33	85.50	0.57
25	5.108	29.99	26.99	0.00	3.00						
30	4.019	23.60	21.24	0.00	2.36						
35	3.233	18.99	17.09	0.00	1.90						
40	2.587	15.19	13.67	0.00	1.52						
45	2.094	12.30	11.07	0.00	1.23						
50	1.725	10.13	9.11	0.00	1.01						
55	1.386	8.14	7.32	0.00	0.81						
60	1.093	6.42	5.78	0.00	0.64						
65	0.878	5.15	4.64	0.00	0.52						
70	0.708	4.16	3.74	0.00	0.42						
75	0.554	3.25	2.93	0.00	0.33						
80	0.431	2.53	2.28	0.00	0.25						
85	0.339	1.99	1.79	0.00	0.20						
90	0.246	1.45	1.30	0.00	0.14						
95	0.154	0.90	0.81	0.00	0.09						
99	0.062	0.36	0.33	0.00	0.04						

Table 10. Raw Data Collected from Lower Brush Creek at Site TMDL01BC

TMDL01BC Brush Cr. @ Wolf Creek Rd. Drainage Area=9.3 mi^2							
Collection Date	***E. coli*** **(col per 100 ml)**	**Dissolved Oxygen mg/L**	**pH**	**Temperature**	**Specific Conductance**	**Flow**	**Comments**
5/5/2005	76	11.46	7.62	12.19	142.6	14.23	
5/12/2005	108	10.34	7.37	17.85	184.0	5.72	
5/12/2005	166					6.05	duplicate
5/19/2005	144	9.57	7.53	18.06	189.5	3.4	
5/24/2005	173	9.1	7.58	16.59	194.1	3.44	
6/17/2005	64	8.82	7.48	19.34	227.1	1.44	
6/22/2005	65	8.87	7.47	22.6	209.4	1.1	
7/13/2005	1414	9.08	7.46	22.15	191.2	3.06	
7/13/2005	1400					3.06	duplicate
9/7/2005	10	5.11	7.21	19.12	276.5	No flow	
9/7/2005	20					No flow	duplicate
10/4/2005	70	6.64	7.55	18.01	230.0	0.33	

B2 Upper Brush Creek Site TMDL02BC

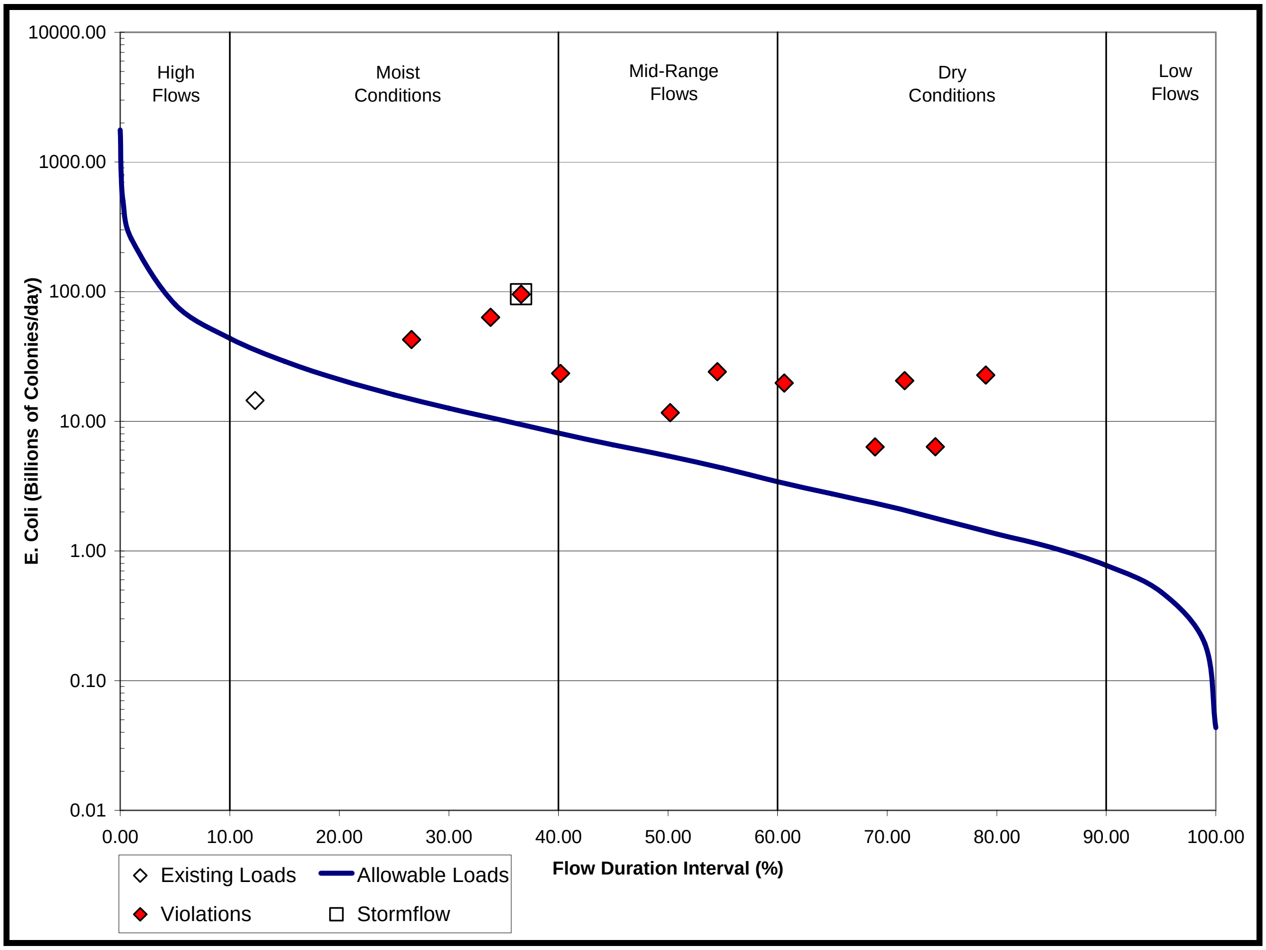

Figure 14. Load Duration Curve and TMDL for Lower Brush Creek, Site TMDL02BC

Table 11. Table of Data Used to Construct Load Duration Curve for Upper Brush Creek (TMDL02BC)

BRUSH CREEK TMDL02BC											
Percentile Rank	Area Weighted Flows	TMDL	LA	WLA	MOS		Date Collected	*E. Coli*	Measured Flow	Flow Percentile	Pollutant Load
0.00794281	301.166	1768.39	1591.55	0.00	176.84		5/5/2005	96	5.71	13.2	13.41
0.1	133.303	782.73	704.46	0.00	78.27		5/12/2005	687	2.54	26.6	42.69
0.2739726	84.770	497.75	447.98	0.00	49.78		5/19/2005	1414	1.83	33.8	63.31
1	43.712	256.67	231.00	0.00	25.67		5/24/2005	687	1.39	40.2	23.36
5	13.577	79.72	71.75	0.00	7.97		6/17/2005	517	0.92	50.2	11.64
10	7.430	43.63	39.27	0.00	4.36		6/22/2005	1414	0.57	60.6	19.72
15	4.934	28.97	26.08	0.00	2.90		7/13/2005	2420	1.61	36.6	95.32
20	3.579	21.02	18.92	0.00	2.10		7/21/2005	1296	0.76	54.5	24.10
25	2.730	16.03	14.43	0.00	1.60		7/27/2005	649	0.4	68.9	6.35
30	2.148	12.61	11.35	0.00	1.26		8/3/2005	2400	0.35	71.6	20.55
35	1.728	10.15	9.13	0.00	1.01		9/7/2005	840	0.31	74.4	6.37
40	1.382	8.12	7.31	0.00	0.81		10/4/2005	3870	0.24	79	22.72
45	1.119	6.57	5.91	0.00	0.66						
50	0.922	5.41	4.87	0.00	0.54						
55	0.741	4.35	3.91	0.00	0.43						
60	0.584	3.43	3.09	0.00	0.34						
65	0.469	2.75	2.48	0.00	0.28						
70	0.379	2.22	2.00	0.00	0.22						
75	0.296	1.74	1.57	0.00	0.17						
80	0.230	1.35	1.22	0.00	0.14						
85	0.181\	1.06	0.96	0.00	0.11						
90	0.132	0.77	0.70	0.00	0.08						
95	0.082	0.48	0.43	0.00	0.05						
99	0.033	0.19	0.17	0.00	0.02						
100	0.007	0.04	0.04	0.00	0.00						

Table 12. Raw Data Collected from Upper Brush Creek at Site TMDL02BC

TMDL02BC Brush Cr. @ SR 1912 bridge Drainage Area=4.97 mi^2							
Collection Date	*E. coli* (col per 100 ml)	Dissolved Oxygen mg/L	pH	Temperature	Specific Conductance	Flow	Comments
5/5/2005	96	10.78	7.69	14.57	165.6	5.71	
5/5/2005	96					6.16	duplicate
5/12/2005	687	9.92	7.44	20.94	207.2	2.54	
5/19/2005	1414	10	7.7	19.69	208.5	1.83	
5/24/2005	687	9.71	7.77	16.27	202.3	1.39	
6/17/2005	517	12.31	8.04	22.6	232.1	0.92	
6/22/2005	1414	9.43	8.16	22.6	215.6	0.57	
7/13/2005	2420	10.28	7.31	20.86	220.5	1.61	
7/13/2005	2100					1.61	duplicate
7/21/2005	1296	9.68	7.42	26.11	284.7	0.76	
7/27/2005	649	9.33	10.14	26.37	280.5	0.4	
7/27/2005	687					0.4	duplicate
8/3/2005	2400	8.71	7.38	25.14	308.7	0.35	
9/7/2005	840	8.95	7.45	19.67	299.9	0.31	
9/7/2005	830					0.31	duplicate
10/4/2005	3870	9.16	7.80	18.80	235.9	0.24	

Note: Only one (1) sample event out of twelve (12) met the water quality criterion of 240 cfu/100ml E. coli.

B3 Lower Crooked Creek Site (TMDL01CC)

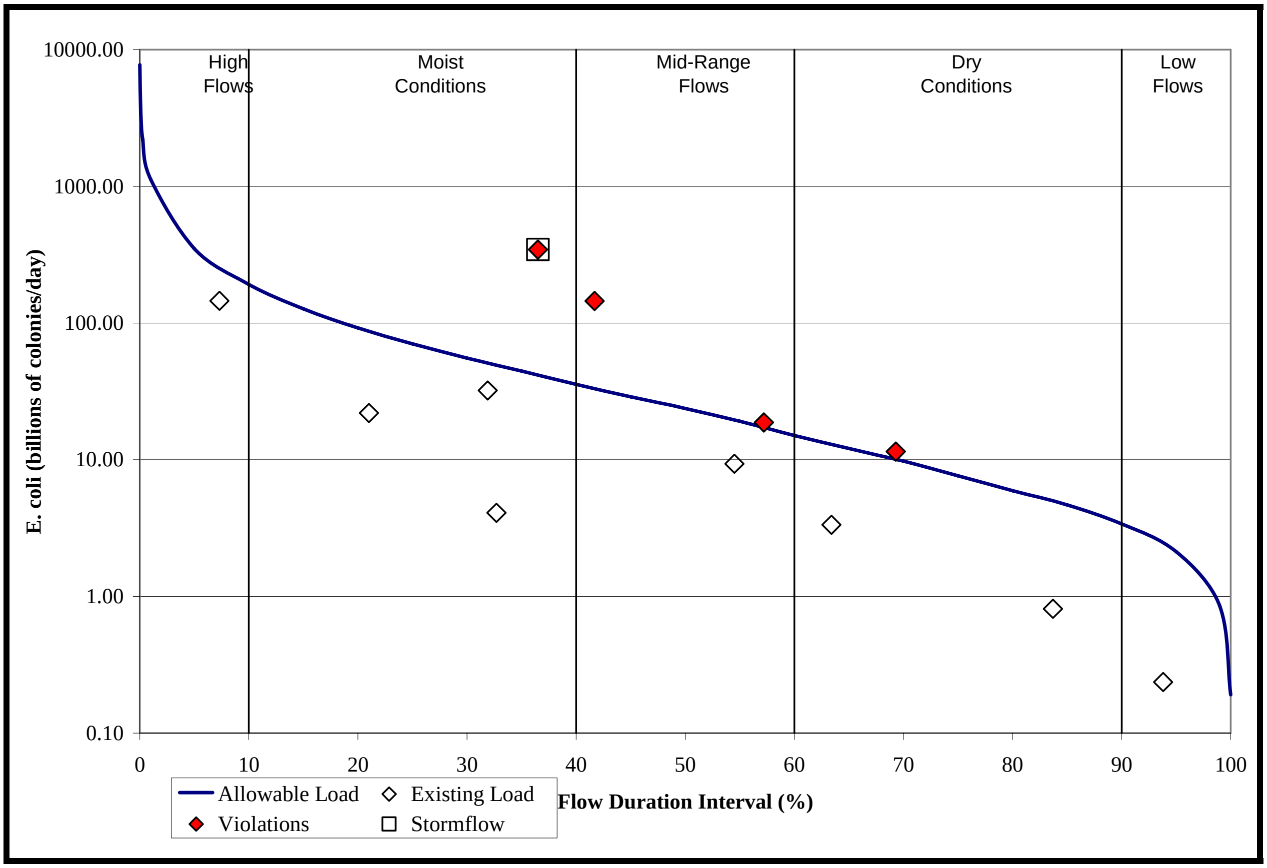

Figure 15. Load Duration Curve and TMDL for Lower Crooked Creek, Site TMDL01CC

Table 13. Table of Data Used to Construct Load Duration Curve for Lower Crooked Creek (TMDL01CC)

CROOKED CREEK TMDL01CC											
Percentile Rank	Area Weighted Flows	TMDL	LA	WLA	MOS		Date Collected	*E. Coli*	Measured Flow	Flow Percentile	Pollutant Load
0.007943	1321.01	7756.72	6981.05	0.00	775.67		5/5/2005	133	44.7	7.3	145.45
0.1	584.71	3433.30	3089.97	0.00	343.33		5/12/2005	60	14.94	21	21.93
0.273973	371.83	2183.31	1964.98	0.00	218.33		5/19/2005	20	8.37	32.7	4.10
1	191.73	1125.83	1013.24	0.00	112.58		5/24/2005	150	8.73	31.9	32.04
5	59.55	349.69	314.72	0.00	34.97		6/17/2005	115	3.32	54.5	9.34
10	32.59	191.37	172.24	0.00	19.14		6/22/2005	62	2.2	63.4	3.34
15	21.64	127.09	114.38	0.00	12.71		7/13/2005	1986	7.09	36.5	344.50
20	15.70	92.19	82.97	0.00	9.22		7/21/2005	1046	5.66	41.7	144.85
25	11.97	70.31	63.28	0.00	7.03		7/27/2005	260	2.95	57.2	18.77
30	9.42	55.31	49.78	0.00	5.53		8/3/2005	272.3	1.72	69.3	11.46
35	7.58	44.51	40.06	0.00	4.45		9/7/2005	40	0.83	83.7	0.81
40	6.06	35.60	32.04	0.00	3.56		10/4/2005	23	0.42	93.8	0.24
45	4.91	28.82	25.94	0.00	2.88						
50	4.04	23.74	21.36	0.00	2.37						
55	3.25	19.07	17.17	0.00	1.91						
60	2.56	15.05	13.54	0.00	1.50						
65	2.06	12.08	10.87	0.00	1.21						
70	1.66	9.75	8.77	0.00	0.97						
75	1.30	7.63	6.87	0.00	0.76						
80	1.01	5.93	5.34	0.00	0.59						
85	0.79	4.66	4.20	0.00	0.47						
90	0.58	3.39	3.05	0.00	0.34						
95	0.36	2.12	1.91	0.00	0.21						
99	0.14	0.85	0.76	0.00	0.08						
100	0.03	0.19	0.17	0.00	0.02						

Table 14. Raw Data Collected from Lower Crooked Creek at Site TMDL01CC

TMDL01CC Crooked Cr. @ ford off Mullins Station Rd. (CR 1140) Drainage Area=21.8 mi^2							
Collection Date	*E. coli* (col per 100 ml)	Dissolved Oxygen mg/L	pH	Temperature	Specific Conductance	Flow	Comments
5/5/2005	133	11.04	7.45	11.3	119.3	44.7	
5/12/2005	60	10.29	7.39	15.52	157.6	14.94	
5/19/2005	20	9.17	7.22	15.16	171.9	8.37	
5/24/2005	150	8.76	7.07	16.3	173.7	8.73	
6/17/2005	115	7.8	7.15	19.04	232.2	3.32	
6/22/2005	62	9.37	7.36	18.99	220.7	2.2	
7/13/2005	2400	7.99	6.97	20.56	196.4	7.09	
7/13/2005	1986					7.09	Duplicate
7/21/2005	1046	7.35	7.29	23.47	250.8	5.66	
7/27/2005	260	6.06	7.13	23.81	237.6	2.95	
8/3/2005	272	6.81	7.1	22.53	300.1	1.72	
9/7/2005	40	7.07	7.04	18.21	286	0.83	
10/4/2005	23	6.9	7.47	16.31	245.5	0.42	

B4. Lower Middle Crooked Creek Site above confluence with UT (TMDL02CC)

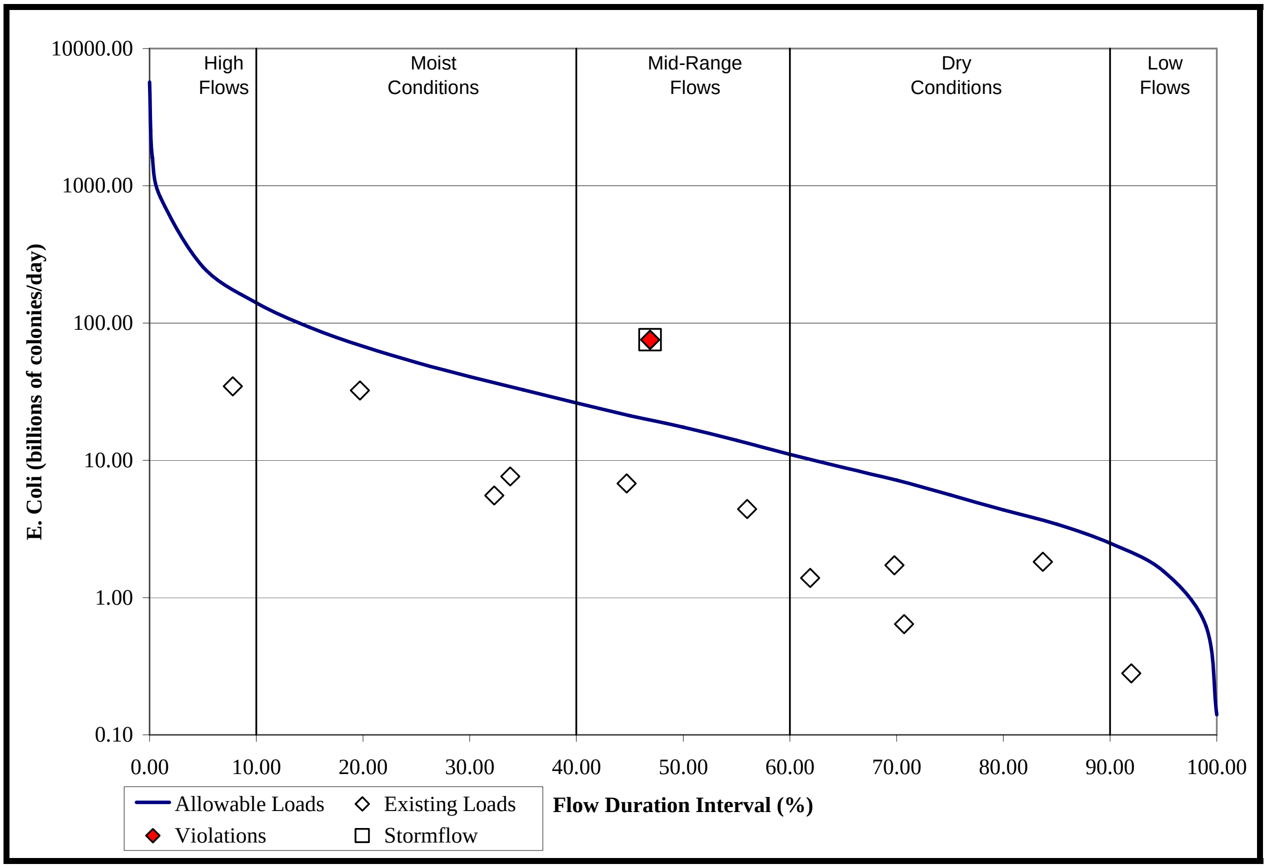

Figure 16. Load Duration Curve and TMDL for Lower Middle Crooked Creek, Site TMDL02CC

Table 15. Table of Data Used to Construct Load Duration Curve for Lower Middle Crooked Creek (TMDL02CC)

CROOKED CREEK TMDL02CC											
Percentile Rank	Area Weighted Flows	TMDL	LA	WLA	MOS		Date Collected	*E. Coli*	Measured Flow	Flow Percentile	Pollutant Load
0.007943	969.55	5693.01	5123.71	0.00	569.30		5/5/2005	46.00	30.75	7.80	34.61
0.1	429.14	2519.86	2267.87	0.00	251.99		5/12/2005	112	11.79	19.70	32.31
0.273973	272.90	1602.43	1442.19	0.00	160.24		5/19/2005	53	5.89	33.80	7.64
1	140.72	826.29	743.67	0.00	82.63		5/24/2005	36	6.30	32.30	5.55
5	43.71	256.65	230.99	0.00	25.67		6/17/2005	33	1.72	61.90	1.39
10	23.92	140.46	126.41	0.00	14.05		6/22/2005	22	1.19	70.70	0.64
15	15.88	93.27	83.95	0.00	9.33		7/13/2005	921	3.36	46.90	75.71
20	11.52	67.66	60.90	0.00	6.77		7/21/2005	75	3.69	44.70	6.77
25	8.79	51.60	46.44	0.00	5.16		7/27/2005	79	2.28	56.00	4.41
30	6.91	40.60	36.54	0.00	4.06		8/3/2005	58	1.22	69.80	1.72
35	5.56	32.66	29.40	0.00	3.27		9/7/2005	120	0.62	83.70	1.82
40	4.45	26.13	23.52	0.00	2.61		10/4/2005	31	0.37	92.00	0.28
45	3.60	21.15	19.04	0.00	2.12						
50	2.97	17.42	15.68	0.00	1.74						
55	2.38	14.00	12.60	0.00	1.40						
60	1.88	11.04	9.94	0.00	1.10						
65	1.51	8.87	7.98	0.00	0.89						
70	1.22	7.16	6.44	0.00	0.72						
75	0.95	5.60	5.04	0.00	0.56						
80	0.74	4.36	3.92	0.00	0.44						
85	0.58	3.42	3.08	0.00	0.34						
90	0.42	2.49	2.24	0.00	0.25						
95	0.26	1.56	1.40	0.00	0.16						
99	0.11	0.62	0.56	0.00	0.06						
100	0.02	0.14	0.13	0.00	0.01						

Table 16. Raw Data Collected from Lower Middle Crooked Creek at Site TMDL02CC

TMDL02CC Crooked Cr. above cave UT; off Crooked. Cr. Rd Drainage Area=16 mi^2							
Collection Date	*E. coli* (col per 100 ml)	Dissolved Oxygen mg/L	pH	Temperature	Specific Conductance	Flow	Comments
5/5/2005	46	11.49	7.56	11.08	117.5	30.75	
5/12/2005	112	10.71	7.26	15.23	158.3	11.79	
5/19/2005	53	10.33	7.51	14.75	176.9	5.89	
5/24/2005	36	9.44	7.48	14.85	179.3	6.3	
6/17/2005	33	10.66	7.53	17.72	248.5	1.72	
6/17/2005	28					1.79	Duplicate
6/22/2005	22	9.3	7.52	18.91	229.3	1.19	
7/13/2005	921	9.56	7.32	20.56	176.4	3.36	
7/13/2005	900					3.36	Duplicate
7/21/2005	75	9.05	7.51	21.14	255	3.69	
7/27/2005	79	7.95	7.43	23.08	249.1	2.28	
8/3/2005	58	8.31	7.36	21.71	317.4	1.22	
9/7/2005	120	8.71	7.42	17.17	299.1	0.62	
10/4/2005	31	8.09	7.81	16.39	251.2	0.37	

B5. Upper Middle Crooked Creek Site (TMDL03CC)

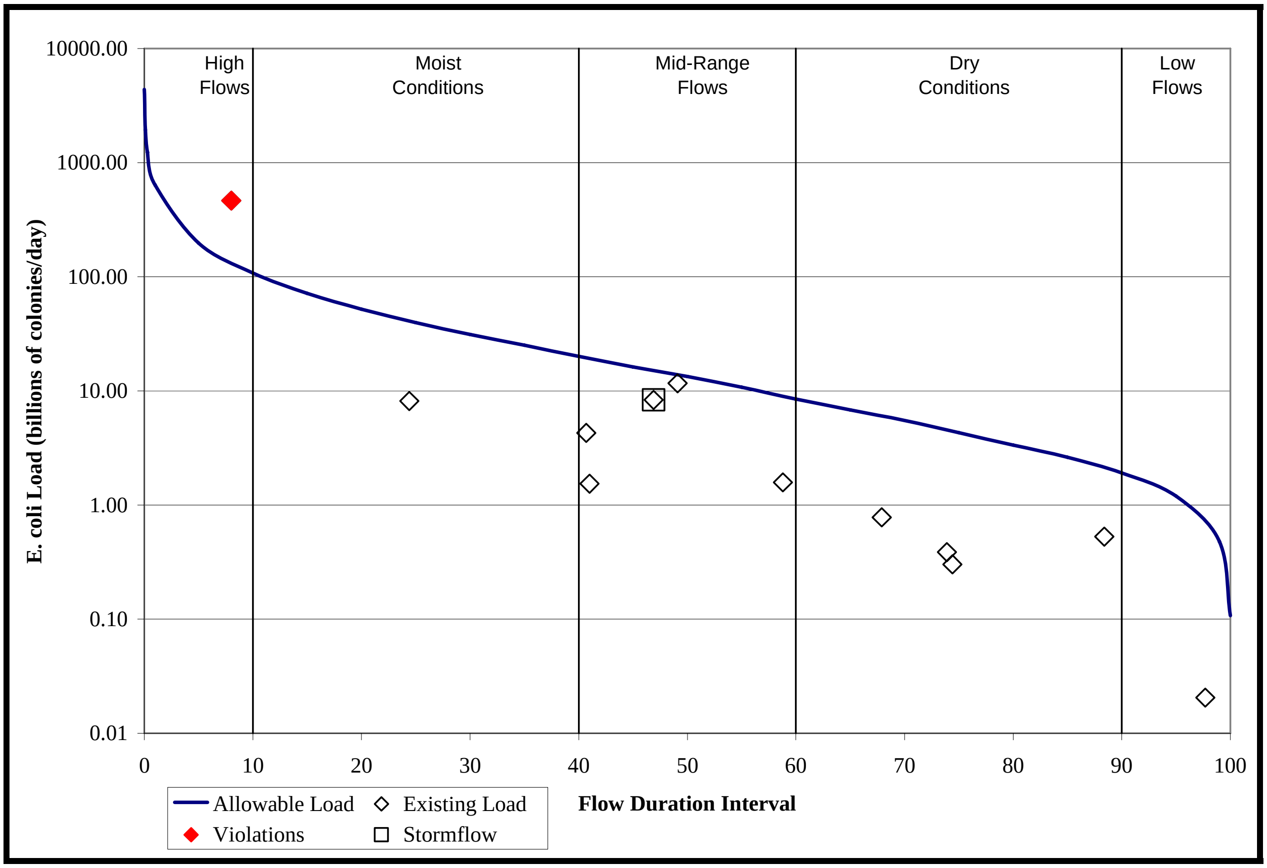

Figure 17. Load Duration Curve and TMDL for Upper Middle Crooked Creek, Site TMDL03CC

Table 17. Table of Data Used to Construct Load Duration Curve for Upper Middle Crooked Creek, Site TMDL03CC

TMDL03CC											
Percentile Rank	Crooked Cr Flow	TMDL	LA	WLA	MOS		Date	*E. Coli*	Discharge	Flow Percentile	*E. Coli* Load
0.007379	745.34	4376.50	3938.845	0	437.65		5/5/2005	816	23.30	8.0	465.17
0.1	329.91	1937.14	1743.42	0	193.71		5/12/2005	48	6.96	24.4	8.17
0.273973	209.79	1231.87	1108.68	0	123.19		5/19/2005	52	3.37	40.7	4.29
1	108.18	635.21	571.69	0	63.52		5/24/2005	19	3.31	41.0	1.54
5	33.60	197.30	177.57	0	19.73		6/17/2005	31	1.03	67.9	0.78
10	18.39	107.98	97.18	0	10.80		6/22/2005	20	0.79	73.9	0.39
15	12.2	71.70	64.53	0	7.17		7/13/2005	131	2.60	46.9	8.333
20	8.86	52.02	46.81	0	5.20		7/21/2005	201	2.37	49.1	11.65
25	6.76	39.67	35.70	0	3.97		7/27/2005	42	1.54	58.8	1.58
30	5.32	31.21	28.09	0	3.12		8/3/2005	16	0.77	74.4	0.30
35	4.28	25.11	22.60	0	2.51		9/7/2005	60	0.36	88.4	0.53
40	3.42	20.09	18.08	0	2.01		10/4/2005	6	0.14	97.7	0.02
45	2.77	16.26	14.64	0	1.63						
50	2.28	13.39	12.05	0	1.34						
55	1.83	10.76	9.69	0	1.08						
60	1.45	8.49	7.64	0	0.85						
65	1.16	6.82	6.13	0	0.68						
70	0.94	5.51	4.95	0	0.55						
75	0.73	4.31	3.87	0	0.43						
80	0.57	3.35	3.01	0	0.33						
85	0.45	2.63	2.37	0	0.26						
90	0.33	1.91	1.72	0	0.19						
95	0.20	1.20	1.08	0	0.12						
99	0.08	0.48	0.43	0	0.05						
100	0.02	0.11	0.10	0	0.01						

Table 18. Raw Data Collected from Upper Middle Crooked Creek at Site TMDL03CC

TMDL03CC Crooked Cr. @ Cooksburg Drainage Area=12.3 mi^2							
Collection Date	***E. coli*** **(col per 100 ml)**	**Dissolved Oxygen mg/L**	**pH**	**Temperature**	**Specific Conductance**	**Flow**	**Comments**
5/5/2005	816	11.39	7.56	10.97	123.2	23.3	
5/12/2005	48	10.9	7.25	13.73	164.6	6.96	
5/19/2005	52	10.07	7.43	13.77	179.8	3.37	
5/24/2005	19	9.57	7.45	14.1	192.2	3.31	
6/17/2005	31	12.62	7.49	15.89	249.1	1.03	
6/22/2005	20	10.16	7.44	16.78	242.1	0.79	
7/13/2005	131	14.42	7.17	11.82	176.5	2.6	
7/13/2005	179						Duplicate
7/13/2005	100						Duplicate
7/13/2005	300						Duplicate
7/21/2005	201	9.47	7.32	18.95	263.1	2.37	
7/27/2005	42	7.09	8.08	19.94	257.1	1.54	
8/3/2005	16	8.32	7.24	19.51	350.3	0.77	
9/7/2005	60	8.35	7.39	17.82	327.6	0.36	
10/4/2005	6	8.49	7.76	16.45	276.9	0.14	

B6. Upper Crooked Creek Site (TMDL04CC)

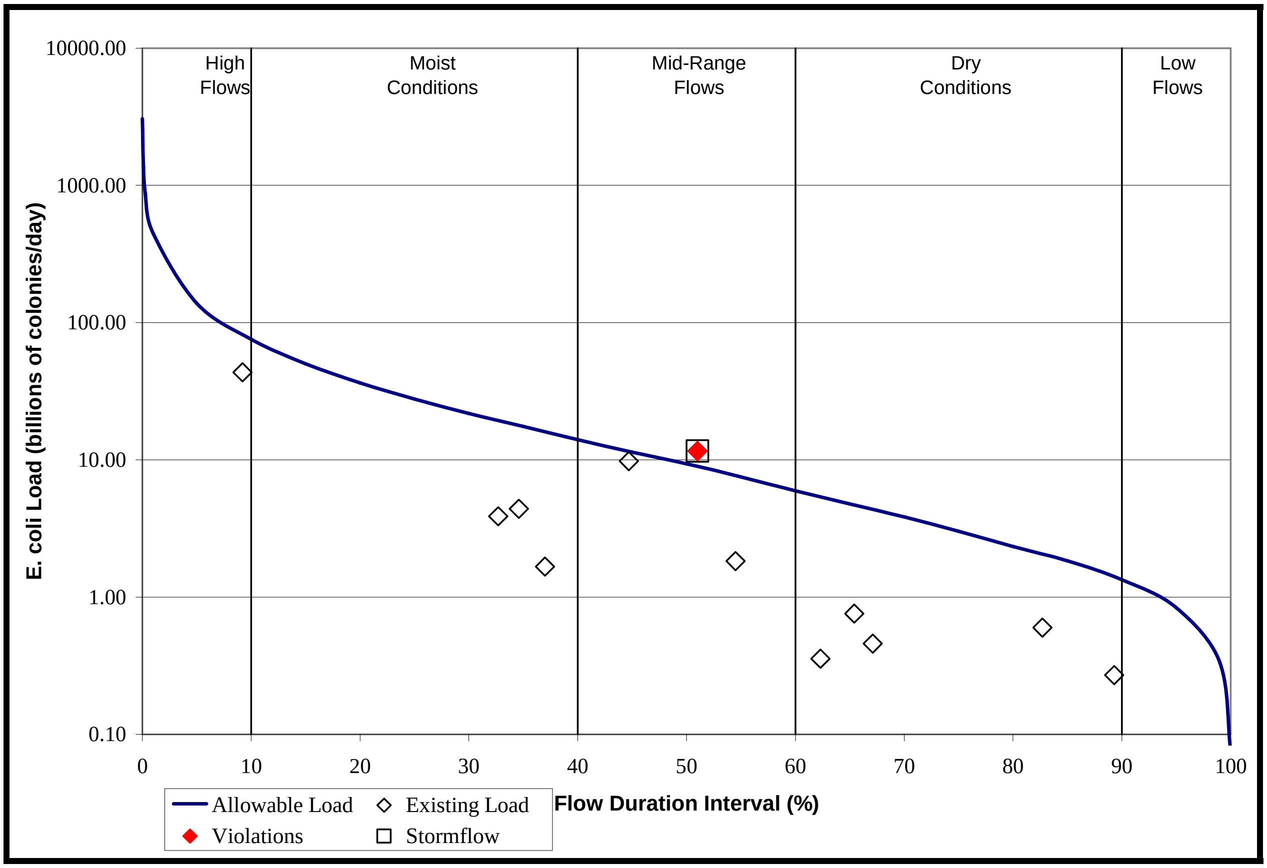

Figure 18. Load Duration Curve and TMDL for Upper Crooked Creek, Site TMDL04CC

Table 19. Table of Data Used to Construct Load Duration Curve for Upper Crooked Creek (TMDL04CC)

TMDL04CC											
Percentile Rank	Crooked Cr Flow	TMDL	LA	WLA	MOS		Date	*E. Coli*	Discharge	Flow Percentile	*E. Coli* Load
0.007379	521.132	3059.99	2753.99	0.00	305.10		5/5/2005	127	14	9.2	43.50
0.1	230.665	1354.42	1218.98	0.00	135.44		5/12/2005	59	3.05	34.6	4.40
0.273973	146.685	861.31	775.18	0.00	86.13		5/19/2005	25	2.73	37	1.67
1	75.638	444.13	399.72	0.00	44.41		5/24/2005	48	3.3	32.7	3.88
5	23.494	137.95	124.15	0.00	13.80		6/17/2005	16	0.91	62.3	0.36
10	12.857	75.50	67.95	0.00	7.55		6/22/2005	25	0.75	67.1	0.46
15	8.538	50.13	45.12	0.00	5.01		7/13/2005	308	1.54	51	11.60
20	6.193	36.37	32.73	0.00	3.64		7/21/2005	201	1.99	44.7	9.79
25	4.724	27.74	24.96	0.00	2.77		7/27/2005	57	1.31	54.5	1.83
30	3.716	21.82	19.63	0.00	2.18		8/3/2005	38.3	0.81	65.4	0.76
35	2.990	17.56	15.80	0.00	1.76		9/7/2005	70	0.35	82.7	0.60
40	2.392	14.05	12.64	0.00	1.41		10/4/2005	48	0.23	89.3	0.27
45	1.936	11.37	10.23	0.00	1.14						
50	1.595	9.36	8.43	0.00	0.94						
55	1.281	7.52	6.77	0.00	0.75						
60	1.011	5.93	5.34	0.00	0.59						
65	0.816	4.77	4.29	0.00	0.48						
70	0.655	3.85	3.46	0.00	0.38						
75	0.516	3.01	2.71	0.00	0.30						
80	0.399	2.34	2.11	0.00	0.23						
85	0.313	1.84	1.66	0.00	0.18						
90	0.229	1.34	1.20	0.00	0.13						
95	0.142	0.84	0.75	0.00	0.08						
99	0.057	0.33	0.30	0.00	0.03						
100	0.013	0.08	0.07	0.00	0.01						

Table 20. Raw Data Collected from Upper Crooked Creek at Site TMDL04CC

TMDL04CC Crooked Cr. below Dry Fork @ Crooked Cr. Rd. bridge Drainage Area=8.6 mi^2							
Collection Date	*E. coli* (col per 100 ml)	Dissolved Oxygen mg/L	pH	Temperature	Specific Conductance	Flow	Comments
5/5/2005	127	11.18	7.55	12.3	141	14	
5/12/2005	59	11.03	7.4	15.81	190.9	3.05	
5/19/2005	25	10.05	7.44	16.09	209.6	2.73	
5/19/2005	20					2.86	Duplicate
5/24/2005	48	9.49	7.49	14.83	209.4	3.3	
6/17/2005	16	8.81	7.35	15.44	299.2	0.91	
6/22/2005	25	9.99	7.41	16.95	257.6	0.75	
7/13/2005	308	10.21	7.33	11.82	220.5	1.54	
7/13/2005	300					1.54	Duplicate
7/21/2005	201	7.66	7.35	20.6	280.5	1.99	
7/27/2005	57	8.13	9.94	19.84	269.3	1.31	
8/3/2005	38	8.7	7.2	19.2	368.7	0.81	
8/3/2005	42						Duplicate
9/7/2005	70	7.87	7.21	16.7	337.4	0.35	
9/7/2005	30					0.37	Duplicate
10/4/2005	48	7.21	7.66	17.8	293.9	0.23	

B7. UT to Crooked Creek Site (TMDL05CC)

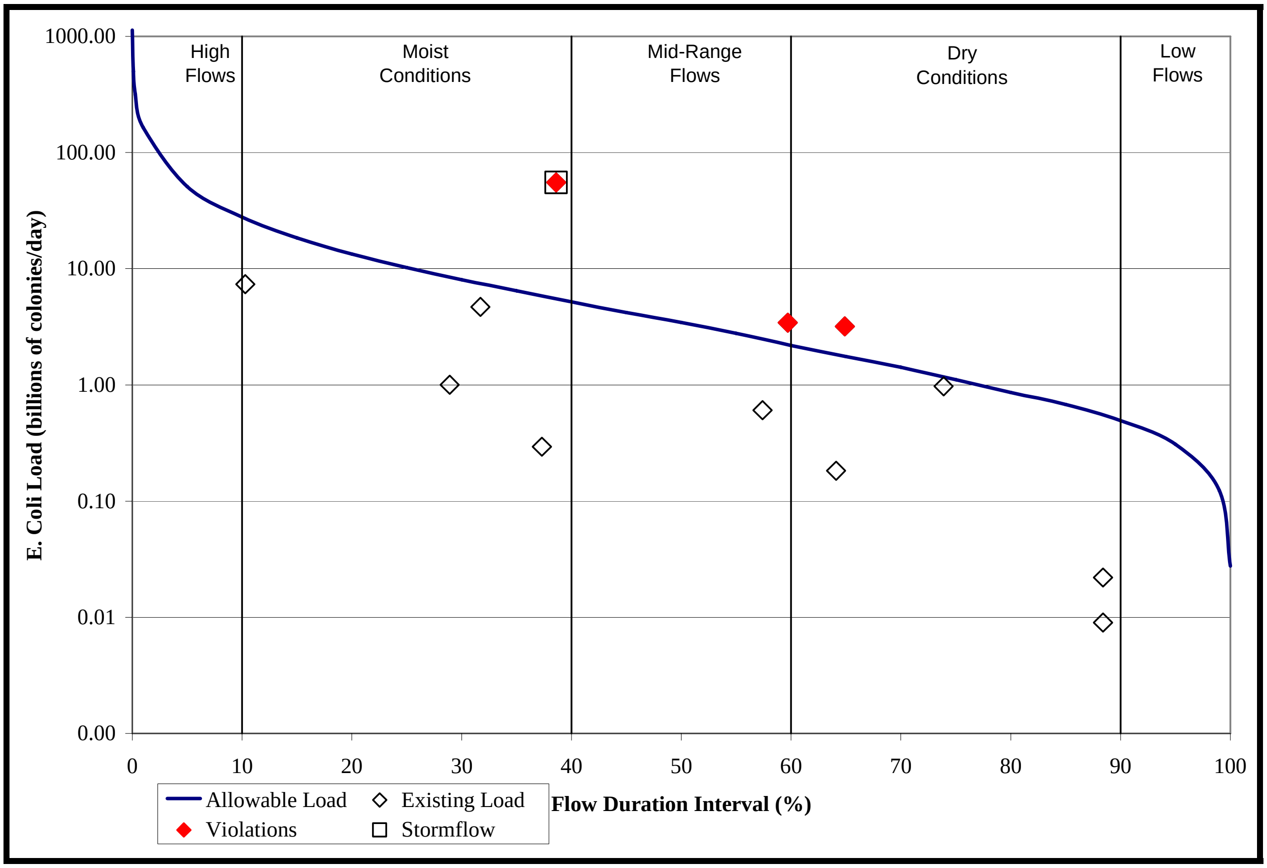

Figure 19. Load Duration Curve and TMDL for UT to Crooked Creek, Site TMDL05CC

Table 21. Table of Data Used to Construct Load Duration Curve for Upper Crooked Creek (TMDL05CC)

TMDL05CC											
Percentile Rank	Crooked Cr Flow	TMDL	LA	WLA	MOS		Date	*E. Coli*	Discharge	Flow Percentile	*E. Coli* Load
0.007379	192.0917	1127.92	1015.13	0	112.79		5/5/2005	65	4.63	10.3	7.36
0.1	85.02421	499.25	449.32	0	49.92		5/12/2005	28	1.46	28.9	1.00
0.273973	54.06867	317.48	285.73	0	31.75		5/19/2005	12	1	37.3	0.29
1	27.88059	163.71	147.34	0	16.37		5/24/2005	150	1.28	31.7	4.69
5	8.659874	50.85	45.76	0	5.09		6/17/2005	59	0.42	57.4	0.60
10	4.739313	27.83	25.05	0	2.78		6/22/2005	24	0.31	64.1	0.18
15	3.147208	18.48	16.63	0	1.85		7/13/2005	2400	0.94	38.6	55.19
20	2.283058	13.406	12.07	0	1.34		7/21/2005	369	0.38	59.7	3.43
25	1.741159	10.22	9.20	0	1.02		7/27/2005	435	0.3	64.9	3.19
30	1.369835	8.043	7.24	0	0.80		8/3/2005	199	0.2	73.9	0.97
35	1.102166	6.47	5.82	0	0.65		9/7/2005	10	0.09	88.4	0.02
40	0.881733	5.177	4.66	0	0.52		10/4/2005	4	0.092	88.4	0.01
45	0.713784	4.19	3.77	0	0.42						
50	0.587822	3.45	3.11	0	0.35						
55	0.472357	2.77	2.50	0	0.28						
60	0.372637	2.19	1.97	0	0.22						
65	0.299159	1.76	1.58	0	0.18						
70	0.241427	1.42	1.28	0	0.14						
75	0.188943	1.11	0.998	0	0.11						
80	0.146955	0.86	0.777	0	0.09						
85	0.115465	0.68	0.610	0	0.07						
90	0.083975	0.49	0.444	0	0.05						
95	0.052484	0.31	0.277	0	0.03						
99	0.02	0.12	0.111	0	0.01						
100	0.005	0.03	0.025	0	0.002						

Table 22. Raw Data Collected from UT to Crooked Creek at Site TMDL05CC

TMDL05CC UT Crooked Cr.; below Crooked Creek Rd. bridge; below cave Drainage Area=3.17 mi^2							
Collection Date	*E. coli* (col per 100 ml)	Dissolved Oxygen mg/L	pH	Temperature	Specific Conductance	Flow	Comments
5/5/2005	65	11.4	7.4	11.3	87.66	4.63	
5/12/2005	28	11.64	7.07	11.55	114.3	1.46	
5/19/2005	12	11.06	7.44	11.72	136	1	
5/24/2005	150	10.97	7.04	11.63	129.8	1.28	
6/17/2005	59	11.45	7.28	12.09	209.5	0.42	
6/22/2005	24	12.35	7.29	13.09	177.9	0.31	
7/13/2005	2400	14.73	7.3	21.24	196.7	0.94	
7/13/2005	3100					0.94	Duplicate
7/21/2005	369	10.72	7.24	12.72	229.8	0.38	
7/27/2005	435	10.83	7.52	12.55	191.8	0.3	
8/3/2005	199	8.72	7.19	15.6	272.9	0.2	
9/7/2005	10	10.57	7.28	12.72	276.9	0.09	
10/4/2005	4	10.85	7.8	12.51	212.1	0.092	